PRODUCT ENGINEERING

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McGRAW-HILL PUBLISHING CO., INC. OCTOBER 1937 VOLUME EIGHT, NUMBER TEN

For Better Professional Recognition

Although there is little difficulty in getting tracers, draftsman, detailers or estimators, companies looking for chief engineers complain that there are few with the proper qualifications. Chief engineers complain that it is difficult to get and hold good engineers in their organizations. An obvious conclusion from these statements is that company officials have difficulty in finding the engineering executives they want because they haven't been paying enough attention to developing them.

Only the occasional company has a systematic procedure for selecting men for the engineering department, or conducts a training course for designing engineers. In addition, there has been a high mortality rate among recent college graduates hired for jobs in the design engineering department. Even worse, not many of the top rank college graduates will accept jobs in the designing department. "Maybe they're too smart to take up designing as a profession," jokingly commented the vice-president in charge of engineering of an internationally known company. But many a truth is spoken in jest. Here's what others say:

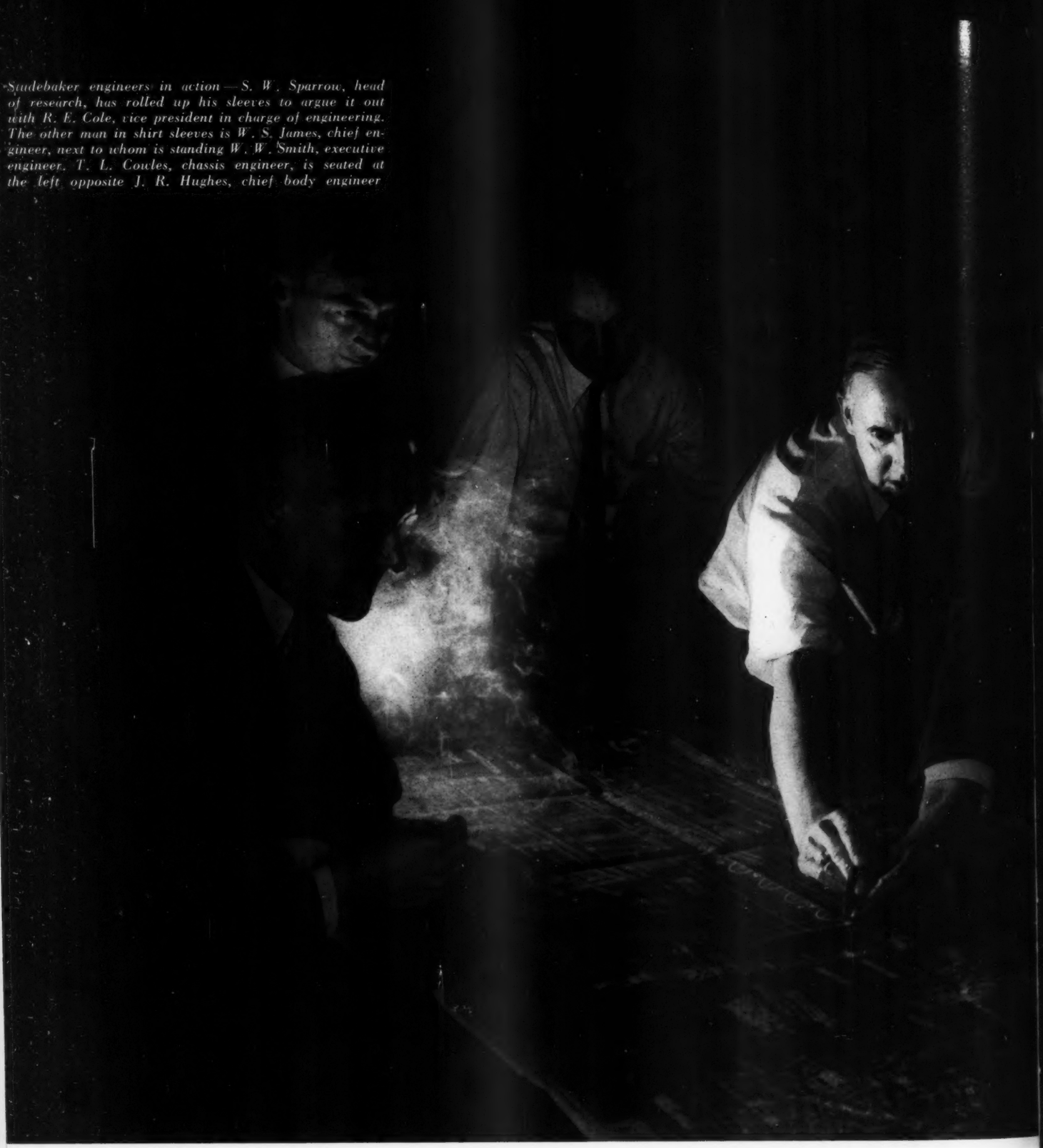
College Seniors—"The work is too confining. . . . . Takes too long to get anywhere. . . . . I don't want to be chained to a drafting board. . . . . No money in it."

Engineering Professors — "Industry doesn't pay enough to attract good men to the designing department. . . . . Even if the man eventually becomes chief engineer his pay will usually be less than that of a successful salesman. . . . . Progress is extremely slow. . . . . Most of the credit, as reflected in the salary check, goes to production and sales managers, especially the latter. . . . . Little opportunity is given for the development of designing engineers. . . . . No one seems to be interested in such training."

Says Industry — "Engineering graduates can't even make a good tracing. . . . . They are too impatient and expect to be given an important job right away. . . . . They lack training in fundamentals. . . . . They don't realize that the only excuse for the existence of a business is to make money."

The more thoughtful employers recognize that progress in the field of engineering design is so rapid that technical training in college cannot hope to keep up with it. They are urging engineering teachers to concentrate on fundamentals and leave the technique to industry. The corollary of this proposition is that industry must be prepared to teach technique to the young graduates it is hoping to develop. Some of the larger companies are handling this training very well but many more will have to undertake it.

It all boils down to this. Regardless of the kind of a job the engineering colleges are doing, and we believe they are doing a fairly good one, industry must recognize that the best grade of material can be procured only by offering a career that will be interesting, highly regarded and professionally recognized, and relatively well remunerated. Engineering design training courses can be made interesting. Recognition is not hard to give, and money makes the mare go. After all, no matter how persuasive the salesman, nor how efficient the production department, few sales will result unless the product is properly designed.



Studebaker engineers in action—S. W. Sparrow, head of research, has rolled up his sleeves to argue it out with R. E. Cole, vice president in charge of engineering. The other man in shirt sleeves is W. S. James, chief engineer, next to whom is standing W. W. Smith, executive engineer. T. L. Coules, chassis engineer, is seated at the left opposite J. R. Hughes, chief body engineer

SUCCESSFULLY ENGINEERED

Paul Hoffman's Definition And the Design of the 1938 Studebakers

What is the secret of the success of the independent automobile manufacturer like the Studebaker Corporation in its competition against the large manufacturers in this field? Here is the answer by Paul Hoffman, president of Studebaker Corporation.

IN BUYING an automobile, the prospect looks for a car that will give dependable service at a reasonable cost and an automobile that has an appearance of which he can justly feel proud. In other words, the buyer is purchasing creative engineering skill and production ability that has transformed materials, useless in themselves, into a dependable eye-appealing machine that will give him the transportation service that he wants.

Successful automobile manufacturing is fundamentally a problem of competitive engineering. That is why Studebaker has always considered its engineering department as the foundation of its business. We recognize that the first requirement is the quality of the engineering. That determines whether or not the product can be manufactured economically and whether or not it possesses points of superiority which will make possible a sales record in competition with other cars.

Competitive engineering is possible because no company, no matter how large, is able to obtain a monopoly on brains. Individually, Studebaker engineers are as good or better than those of any other automobile manufacturer. But our organization, being relatively small, affords many advantages to our engineers. They are not hampered by red tape, divided authority or the lack of closely coordinated effort, such as necessarily is more or less characteristic of the conditions of operation in the larger organizations. At Studebaker we get not only direct action within the engineering department but also a cooperative attitude throughout the whole organization, which is evidenced by our engineers working in close harmony with all other departments—production, sales, advertising and servicing.

A natural accompaniment to a closely knit, quick acting, aggressive engineering organization is a high standard of sound technical skill and the capacity for creative thinking and an unfailing cooperative attitude. And, quite naturally perhaps, in addition to these three attributes, Studebaker engineers are characterized by their open mindedness and their skepticism, the former including a "commercial" point of view that makes our engineers alert to recognize what people like and what they dislike about current models and to discern what buyers will want next year and in the years to come. This last might be termed as the engineering philosophy that is based on "Here's something people want—let's make our cars that way." This means no pet hobbies, no stubborn pride of opinion, and the ready acceptance of a solution other than one's own.

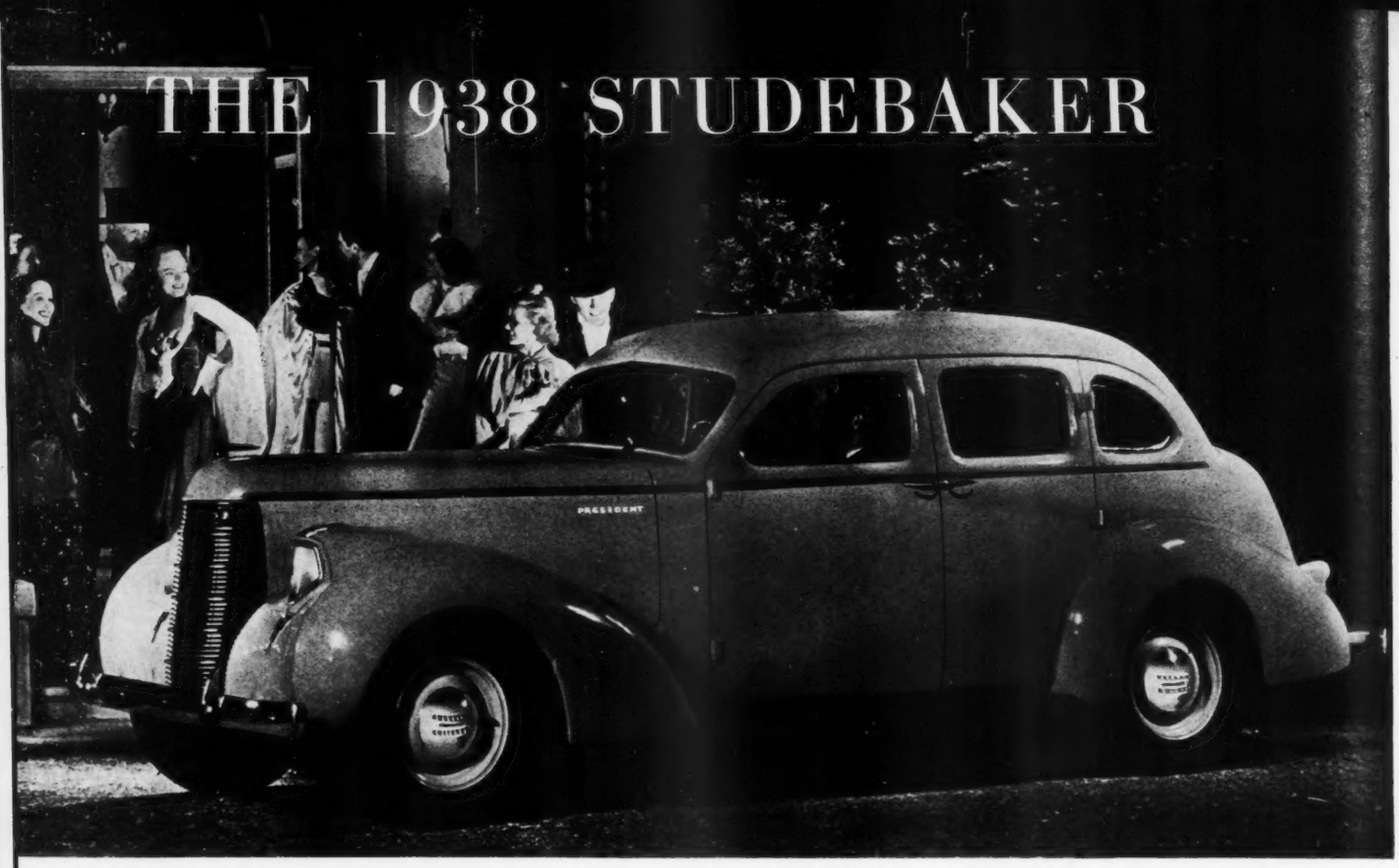
It sounds paradoxical, but along with their broadmindedness, Studebaker engineers are the most skeptical of men and refuse to accept any new idea, their own or anybody else's, until they have put it to every test that skepticism can suggest and technical skill can devise.

Thus it is that Studebaker engineers demand of the management, and get, all equipment and every resource required to make their skepticism a constructive virtue—research laboratories, proving ground, and the privilege of endless and costly experiments. They refuse to risk their own or Studebaker's reputation on make-shifts and guesses. Their heads and not their hearts, their brains and not their emotions, dictate their decisions. And I believe our pride is pardonable when we say that Studebaker engineers possess, in an active sense and to a profound degree, these five attributes that I have outlined and which seem to be most essential in an engineer as an engineer.

Paul G Hoffman

Young and aggressive Paul Hoffman became president of Studebaker at the brink of the depression when the company's financial position was in a bad way because of overexpansion. To the amazement of financiers, he pulled the company out of receivership in the midst of the world's worst business depression. He attributes a large part of this to successful competitive engineering

THE 1938 STUDEBAKER



STUDEBAKER ENGINEERING is in charge of vice-president R. E. Cole. The complete organization is shown in the accompanying chart. Engineering offices, sample-body shops and research laboratories are all housed in the same building thereby enabling the engineers to follow closely the work in various stages of development.

Office doors are "always open." Scheduled engineering conferences are held once every two weeks. Informal discussions between heads of various engineering divisions are frequent and, because Studebaker engineering and production is all "self-contained," decisions need not wait upon advices from associated or subsidiary companies. Nor are engineering activities and decisions hampered or circumscribed by interlocked engineering design that requires interchangeability of parts between different makes of car. Studebaker engineers are free to cut their designs out of the whole cloth.

With the various engineering divisions working closely together and in intimate contact with the sales and other departments, the conditions are highly conducive to quick concerted action and aggressive engineering development. Backed by a management which is conscious of the fact that the first requirement for a successful product is sound engineering, the engineers have "all equipment and every resource" in order that their aims may be achieved. Their success in competitive engineering is evidenced by the many important firsts they have to their credit. Free wheeling, the hillholder, and the cylindrical door latch are three outstanding ones.

Further engineering achievements are incorporated in the 1938 Studebaker models, as described and analyzed here in detail. The chassis frame is lighter, but five times more rigid than previous designs; a new design of transmission has practically eliminated the "kick-up" or tunnel in the floor of the front compartment; and an improved front spring suspension gives better riding, easier steering and has unusual safety features. The body is three inches wider and the interior appointments have been redesigned, rearranged and greatly improved with respect to appearance, suitability and safety. With reference to the outside appearance, gadgets are entirely absent and smooth surfaces with flowing lines characterize the design.

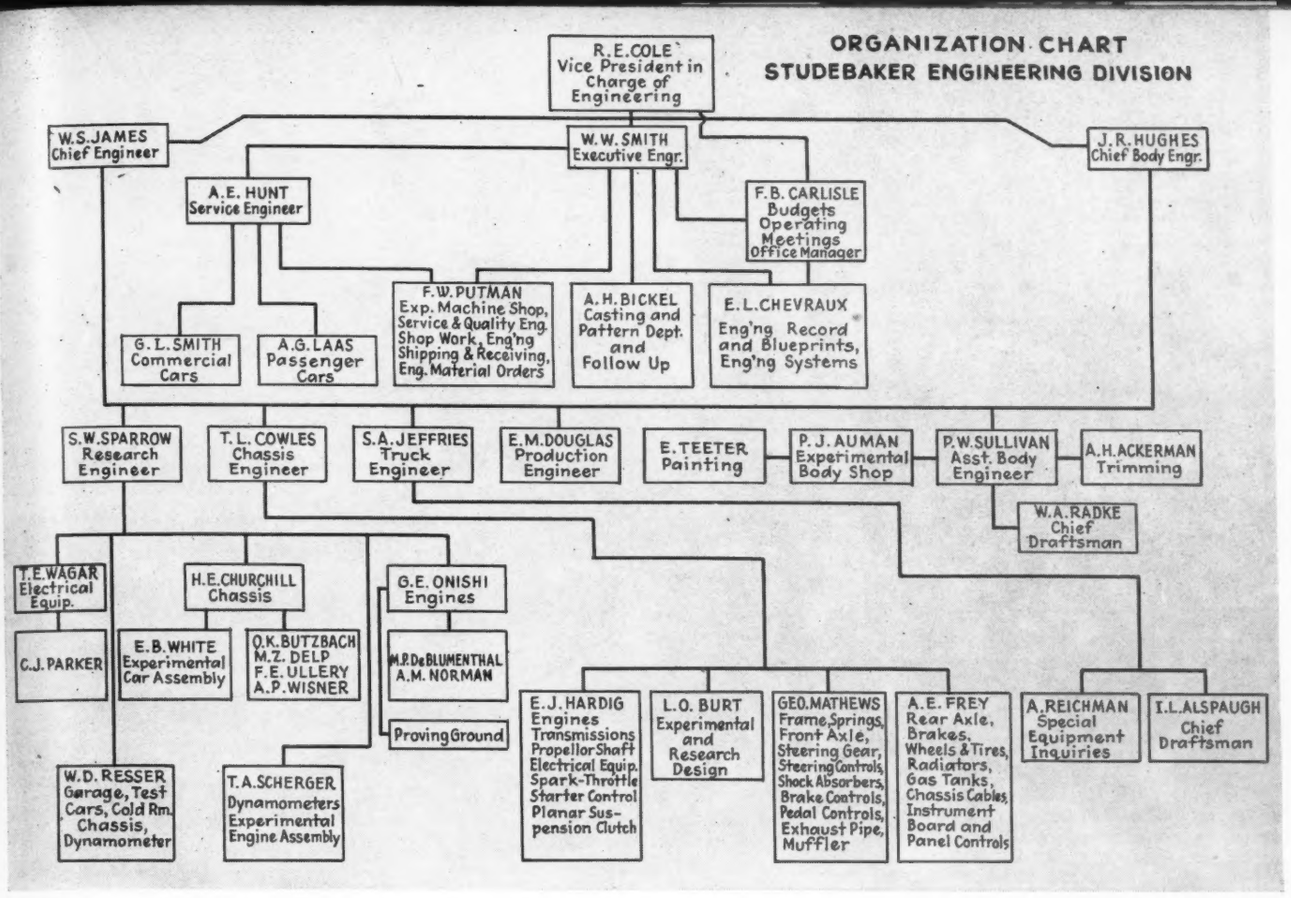
In Fig. 1 are shown the usual design of X-type chassis frame and the redesigned frame for the Studebaker 1938 model. In the chassis frame for the 1937 Dictator, the X-members do not cross but are welded and riveted to a box-shaped centerpiece. It is evident that in such a design the discontinuity of the X-members will cause changes of direction of stress and cause stress concentration. But of even greater importance, such a design inherently lacks rigidity. The centerpiece, when subjected to twisting moments, deflects, and the deflections are greatly multiplied when measured at the corners of the frame.

At the top in Fig. 1 is shown the frame as redesigned for the 1938 models. Specific credit for this design belongs to George Matthews in collaboration with H. E. Churchill. In the development, their aim was to do away with the centerpiece and make each of the X-members an unbroken straight line from one side of the frame to the other, thereby making it much more rigid and lighter.

The simplicity of the new design bespeaks its ingenuity. Cutting out a section of the web of the channels where they cross made possible the desired results. But, as an added feature, the depth of the channel increases as the intersection point of the X-members is approached. This greatly increases the section modulus and moment of inertia at the center, thereby giving greater strength and stiffness.

The metal in the web that was cut out to permit the X-members to cross in a straight line, has little effect on the strength and stiffness because most of that metal was close to the neutral axis. Thus in the new design the stress lines are continuous, localized stresses and deflections have been eliminated and no part of the X-construction is subjected to direct torsion. The new frame for the 1938 model weighs 52 lb. less and is 5½ times stiffer than the frame for the 1937 model, although the gage thickness of the steel is the same in both designs. In the fabrication of the frame, welding has to a large extent replaced riveting.

Another improvement desired in the 1938 models was the elimination of the kick-up or tunnel in the floor of the front compartment, over the transmission case. Road clearance requirements made it impossible to lower the transmission case, while public demand for low cars did not permit raising the floor. A study of the transmission design made it evident that nothing would be gained



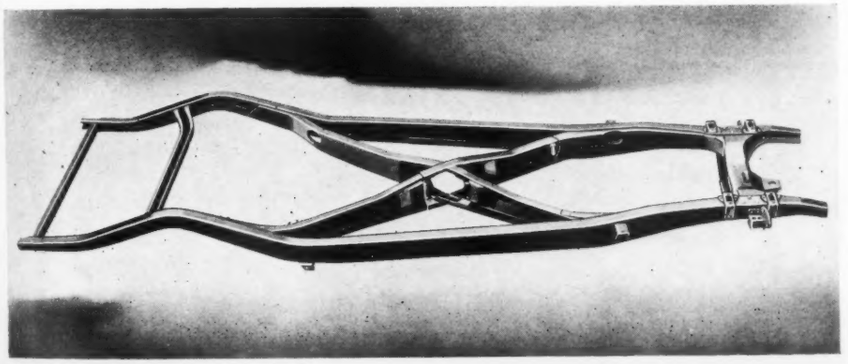
in attempting to design a smaller transmission since gears and shafts were as small as strength requirements allowed.

The solution of the transmission problem was highly ingenious in its simplicity and strikingly illustrates that Studebaker engineers are not hidebound by traditions or conventions. Both the old and new designs are shown in Fig. 2. The only basic difference between the two is that the new one has been turned 90 deg. about its axis, thereby putting the shifting fork on the side of the case or assembly, instead of on top of it as in the usual and conventional designs. This, of course, required a number of changes in the details of the shifting lever, forks, detents and other parts, but the transmission gears, shafts and associated parts remained substantially the same.

By this simple redesign of the transmission assembly the distance from the top of the case to the center line of the crankshaft or mainshaft of the transmission remained about the same, but the distance from the center line of the case or assembly to the lowest point was reduced approximately 1¾ in. To take advantage of this, the engine was moved forward about three inches nearer to the front wheels, permitting it to be lowered about 1¾ in. and thereby lowering the transmission assembly an equal amount. This enabled the "hump" or kick up in the floor to be lowered correspondingly, with the result that in the 1938 model the floor in the front compartment is only slightly higher in the center than at the sides.

One of the major research projects at Studebaker has been the work on leaf springs and front-wheel spring suspensions with the purpose of developing a design that would possess superior riding and steering-control qualities.

The first problem was to find out the correct camber for the different leaves of the spring so that when in service every leaf would be subjected to the controlled maximum stresses. Spring assemblies were made wherein the different leaves were given certain cambers which were decided on by the results of calculations and modifications of these



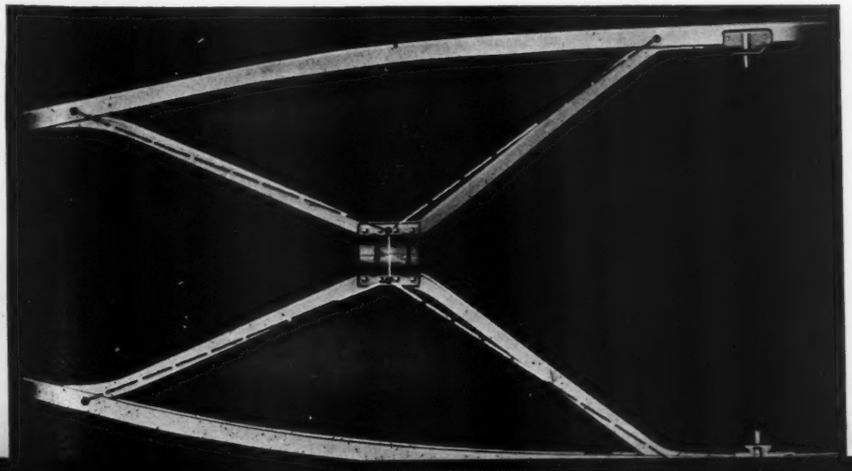


Fig. 1—Previous design of X-type chassis frame and the improved design wherein the box-shaped centerpiece has been eliminated and the X-members cross in straight lines. Less weight and greater rigidity are obtained in the new design

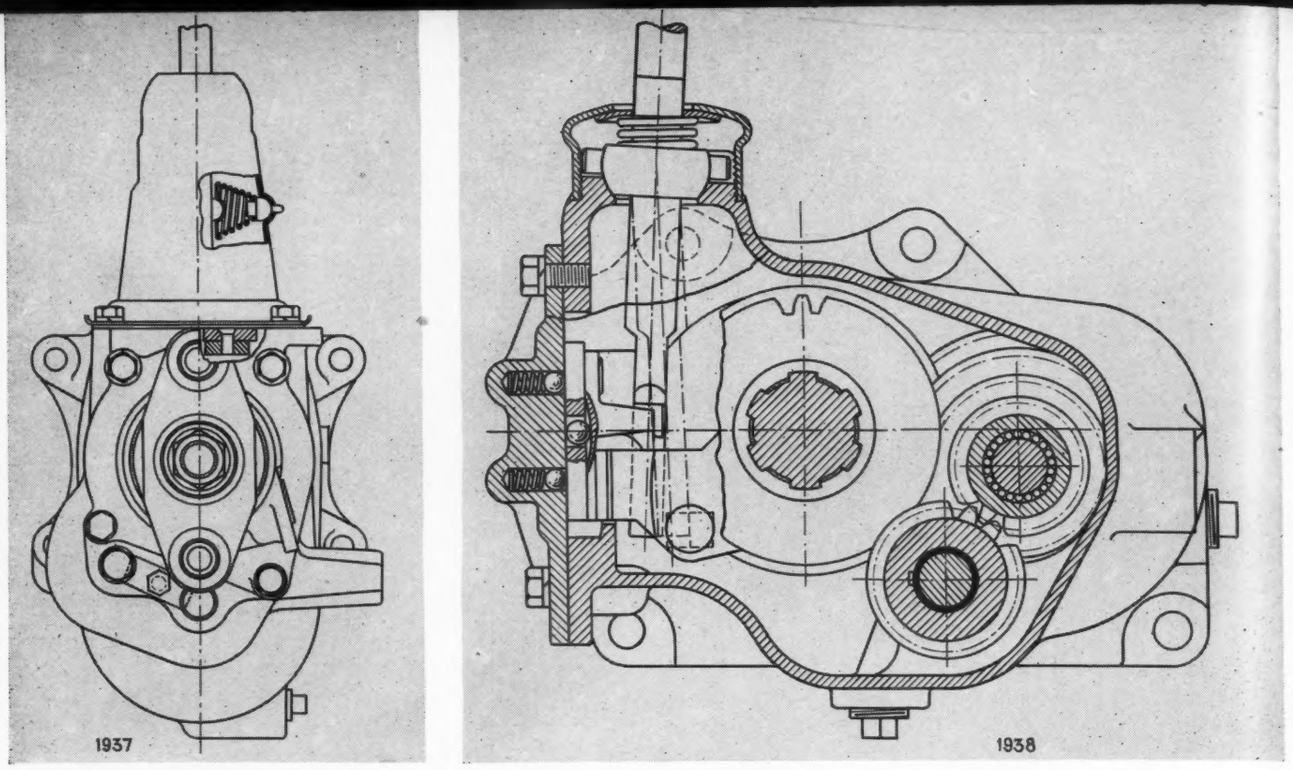


Fig. 2—Old and new design of transmission. By merely turning the transmission on its side and making a few minor changes the vertical height was reduced which enabled the floor over it to be lowered

results. The spring assemblies were then subjected to fatigue tests in which the springs were stressed to the maximum load that they would be subjected to in service.

During the fatigue tests the springs were periodically taken out of the testing machine and closely inspected after a given number of stress applications. The beginnings of fractures were noted and broken leaves were replaced. In this way there was developed a design of front spring with the cambers such that every leaf except the main and second one has the same fatigue life, the two latter being considerably stronger. Thus even if a spring leaf did break because of unusually rough road conditions, it would be one of the secondary or shorter leaves that would break, and this would have no serious consequences.

Similar spring tests were also conducted to investigate the effect of the spring clip and the method of anchoring the spring in the center housing. The former design called for one clip at the center of the spring with a spring seat a few inches to each side of the center as shown in Fig. 3. Thus the two halves of the front spring acted as a continuous beam and not as two independent cantilever beams. Hence deflections and stresses imposed by one of the wheels on its half of the spring were partially transmitted beyond the spring clip at the center of the spring. Under these conditions each half of the spring was subjected to all of the stresses imposed by its wheel plus a portion of the stresses imposed by the other front wheel and, for that reason, high secondary stresses were developed at the spring clip.

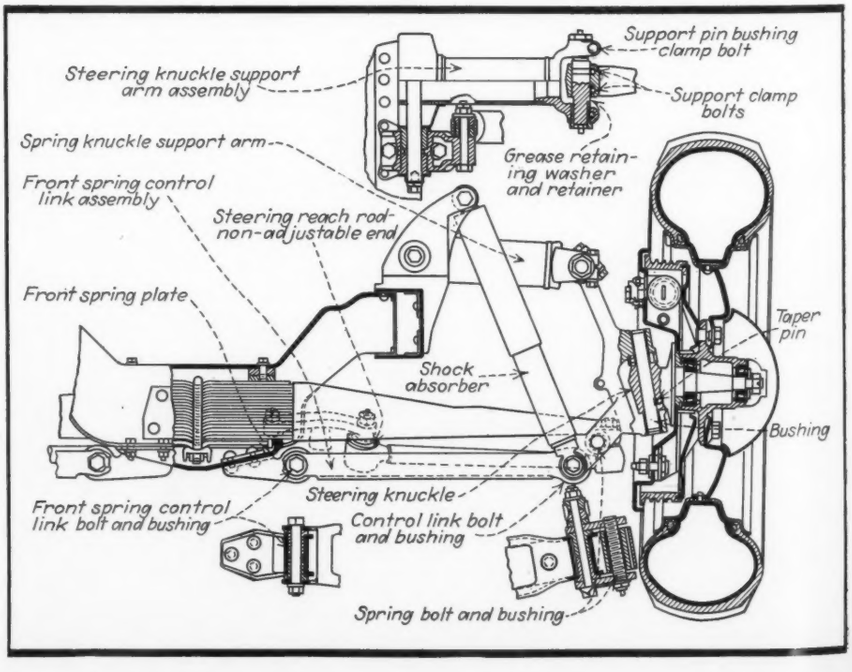
Fig. 3—Previous design of spring anchor with one clip at the center and a spring seat to each side, the two halves of the spring virtually acting as one continuous beam

In order to overcome this condition, the 1938 models have two clips to anchor the front spring, the clips also clamping firmly in place a relatively heavy housing that extends between the clips, as shown in Fig. 4. Each half of the front spring then acts as an entirely independent cantilever and none of its stresses and deflections will be transmitted to the other half.

Mention was made of possible spring breakage resulting from unusual road conditions. As can be seen in Fig. 4, even should the entire front spring break, the wheel would be held in position by the front spring control link, thereby preventing loss of steering control.

With further reference to the design of the leaf springs, the main and second plate of each spring is ground to a smooth surface on the side that will be in tension. This greatly increases the fatigue life of the spring as it takes out the hair line cracks that might be present in the surface and serve as the beginnings of fatigue failure. Only 0.004 in. is ground off the surface, enough to accomplish the desired result.

Test cars equipped with the new front



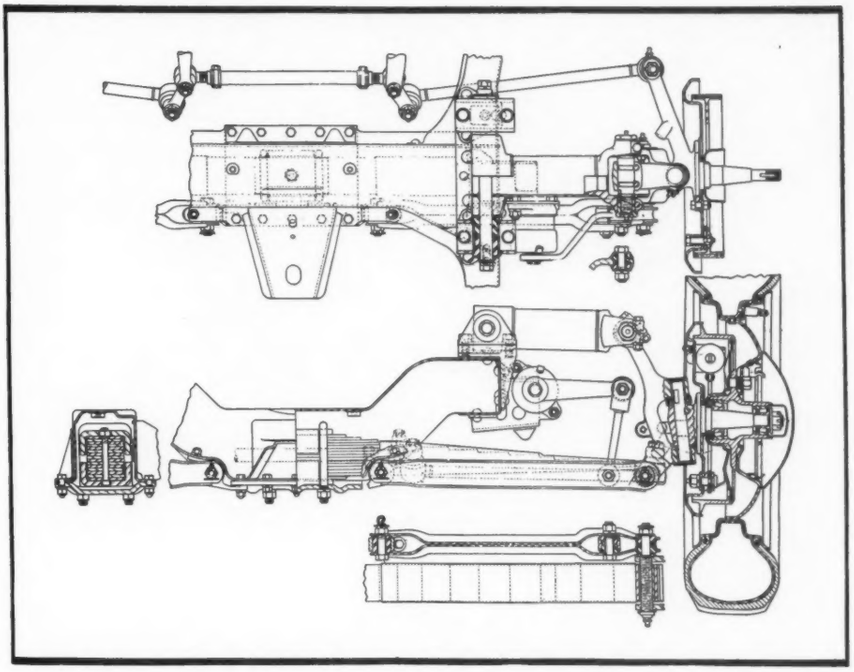


Fig. 4—By using two clips to anchor the front spring, each half acts as an entirely independent cantilever. The control link is designed so that even should the spring break entirely, control of steering would not be lost

spring suspension have been driven more than 30,000 mi. over the roughest kind of road without spring failure. This is equivalent to more than 150,000 mi. of driving over ordinary roads.

In line with the improved front spring design, it was desired to further improve the suspension and steering gear. Comparing Figs. 3 and 4, it will be noticed that the virtual center of deflection of the spring in the new design is considerably nearer to the center line of the car. This is indicated by the positions of the front spring control-link bolt. The advantage of this is that it permits longer steering reach rods and brings the inner ends nearer to each other. This in turn paved the way for the improved steering linkage shown in Fig. 5 which is a "worm's eye" view of the 1938 Dictator model.

In this design the steering gear arm connects directly to the reach rod for the left wheel and also to a connecting or tie rod that fastens to an idle lever pivoted to a bracket on the chassis frame. The steering reach rod for the right wheel is connected to this idle lever. As can be seen from Fig. 5, the whole steering linkage is symmetrical and the design is inherently such, by virtue of the symmetrical construction, that the two front wheels must always move in unison and be parallel to each other.

The design of the crankshaft vibration damper and fan pulley assembly is shown in Fig. 6. Tapered rubber bushings for the assembly bolts are used in place of cylindrical bushings. This puts the rubber under initial compression thereby more efficiently preventing vibrations from being transmitted.

Although the mechanical design features described above are of great significance, the most striking change in the 1938 Studebaker models is their appearance. Raymond Loewy, the well known industrial stylist, was commissioned as consulting engineer to work with the Studebaker engineers in developing a body style that would be outstandingly attractive.

In the 1938 Studebaker bodies a striking effect has been attained by the elimination of all gadgets and unnecessary projections. The surfaces are smooth. Hood louvers have been eliminated and front fenders sweep into the running board instead of attempting to imitate the airplane wheel boot. Numerous other features can be seen in the illustration.

Body interiors have been made more pleasing and safer. All knobs have been recessed or located where they are not in the way. Instruments and control knobs are directly in front of the three-spoke banjo-type steering wheel. Door locks are the cylindrical type developed by Studebaker and first used in 1937 models. (See *P. E.*, Dec. 1936, p. 474).

The bodies are three inches wider and roomier. With the engine moved forward three inches, the front and rear seats were likewise moved forward, giving an extra large baggage compartment.

All 1938 Studebaker models are equipped with the "hill holder," a Studebaker design feature that was introduced in the 1937 models. (See *P. E.*, Dec. 1936, p. 474). Automatic pneumatic gear shift is optional.

Many other new design features and improvements in the 1938 Studebakers could be cited and described. Those presented here are only the major significant developments offered to American automobile buyers in the 1938 Studebaker models—the fruits of the technical skill and creative ability of engineers whose philosophy is, "Here's something people want—let's make cars that way." Backed by an engineering-conscious management, they did it.

Fig. 5—In the improved steering mechanism the linkage is symmetrical thereby giving identically the same motion to both steering knuckle arms

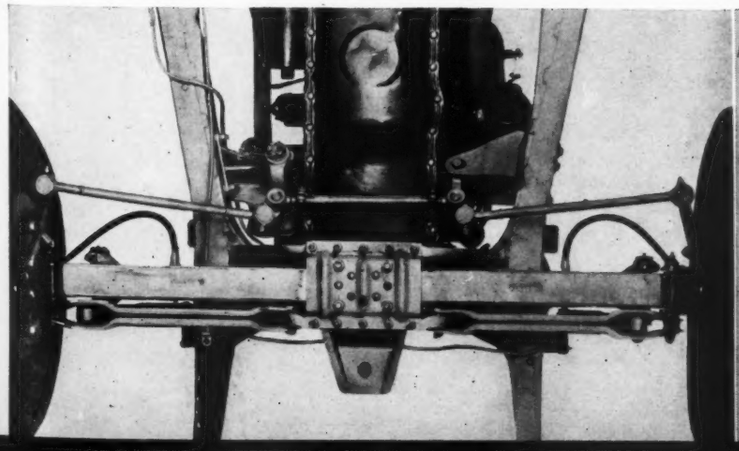
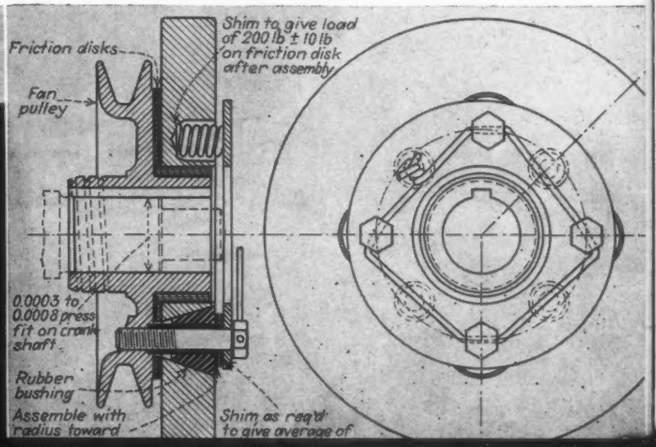
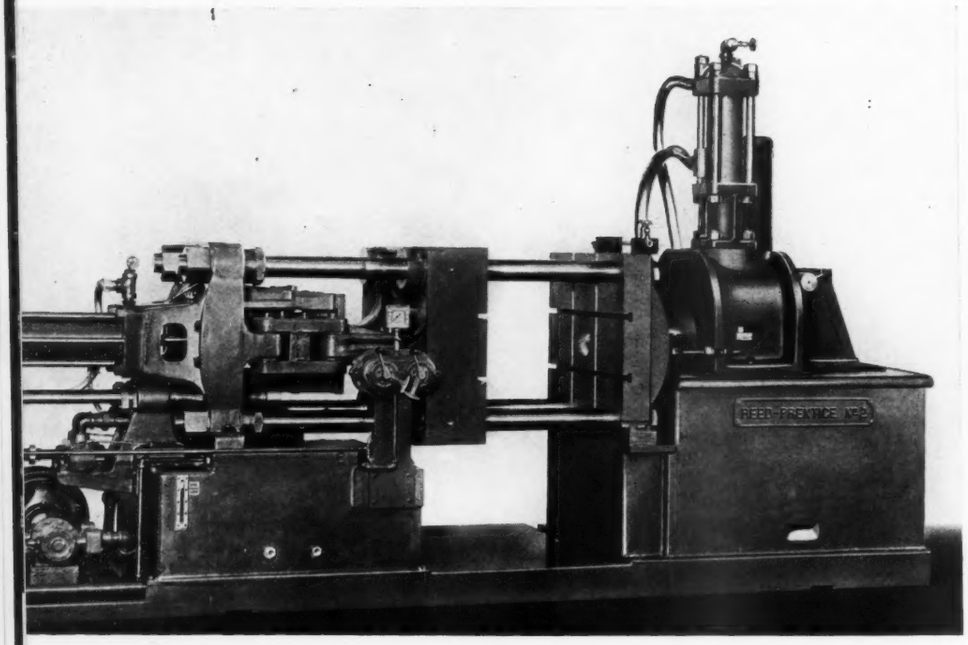


Fig. 6—Improved design of vibration damper and fan pulley assembly wherein tapered rubber bushings are used to permit putting the rubber under a predetermined initial compression


Friction disks
Fan pulley
Shim to give load of 200 lb ± 10 lb on friction disk after assembly
0.0003 to 0.0008 press fit on crank shaft
Rubber bushing
Assemble with radius toward
Shim as req'd to give average of

MODERN DESIGNS

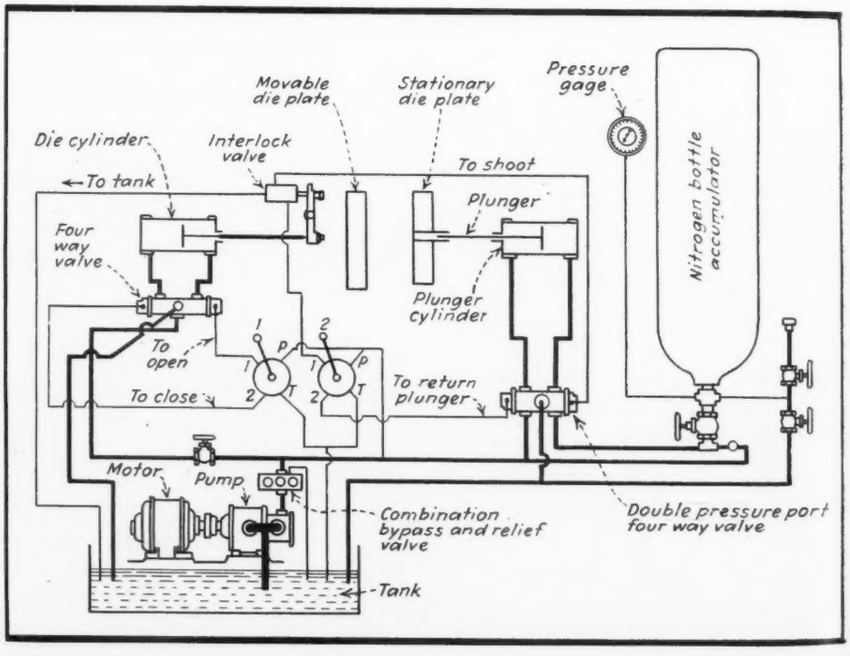


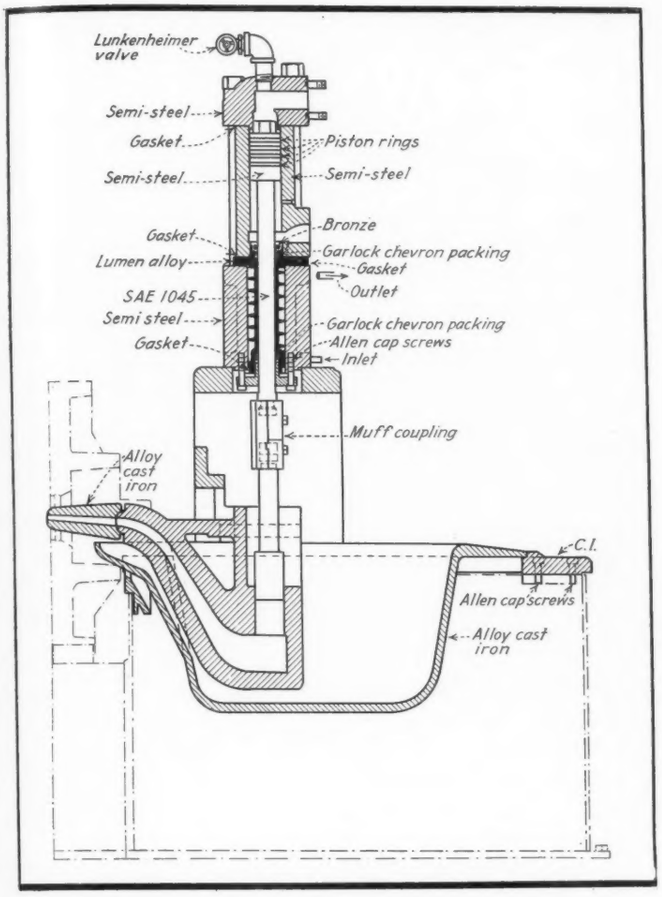
LOCKING PRESSURE, sufficient to hold the dies closed under the heavy pressure applied to the molten metal, must be provided since otherwise serious metal spattering will occur and heavy fins will be produced. Although direct hydraulic pressure could be used, it would necessitate use of large pump and present possible hazard of die-opening if break in pressure system should occur. Positive-locking compound toggle is therefore used. Force is applied by two sets of links, one bearing at each side of die plate. To minimize wear, the cast steel toggles are bushed with S.A.E. 2315 steel made glass-hard by pack-hardening and the pins are heat-treated and hardened S.A.E. 3250 steel.

Accumulator, Compound Toggle, and Injection Cylinder Feature Die-Casting Machine

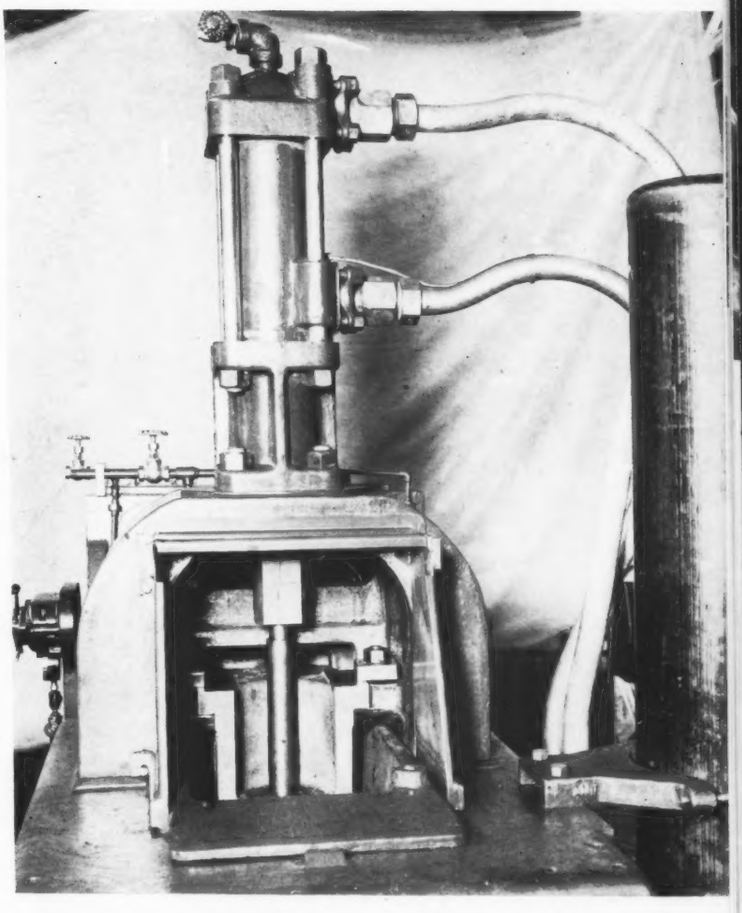
Nitrogen-filled steel bottle acts as accumulator for this self-contained Reed-Prentice zinc die-casting machine. The Vickers type hydraulic pump runs continuously, furnishing pressure oil directly to cylinders for all operations except injection stroke. For latter, accumulator supplies high-pressure oil. Result: Substantially uniform load permits use of relatively small pump driven by 5-hp. motor.

HYDRAULIC CIRCUIT reveals principle of operation. Double-pressure-port, four-way valve of Vickers type feeds high-pressure oil on plunger injection stroke only. Control valve is spool-shaped, is hydraulically operated from a pilot line and is controlled by one of the two hand-actuated rotary valves. The other hand valve controls another four-way hydraulic valve connected to the die-operating cylinder which is interlocked with first hand valve, as shown, so that metal cannot be fed until dies are closed and locked.



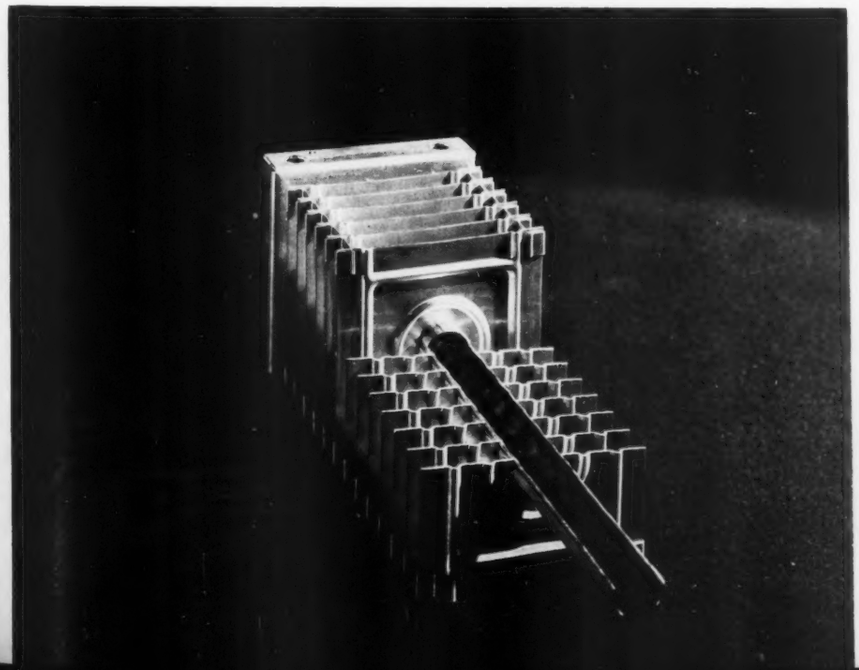


INJECTION CYLINDER AND PLUNGER are semi-steel castings, as also is the cylinder head which must withstand pressures up to 1,000 lb. per sq.in. Originally, cored passages for high-pressure oil were provided in the castings but porous spots, hard to avoid, sometimes caused leakage. Passages within the die castings are now kept as short as possible and the oil is carried through heavy external copper tubing.

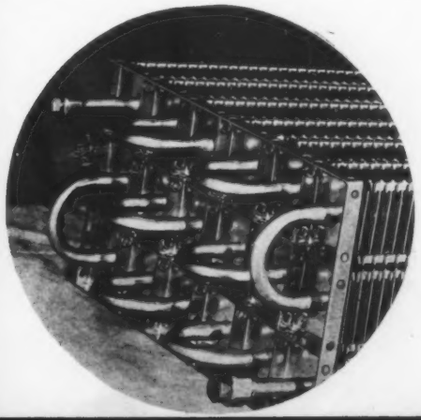


SERVICING AND FILLING are facilitated by the generously proportioned opening in the metal-injection end of the machine. Plunger coupling is readily accessible and ample space is provided for feeding of ingots and of sprues or gates which are sometimes broken from the die casting immediately after it is taken from the die and are returned to the pot while still hot. Also shown is nitrogen bottle.

Simple Design Detail Boosts Fin-Coil Efficiency



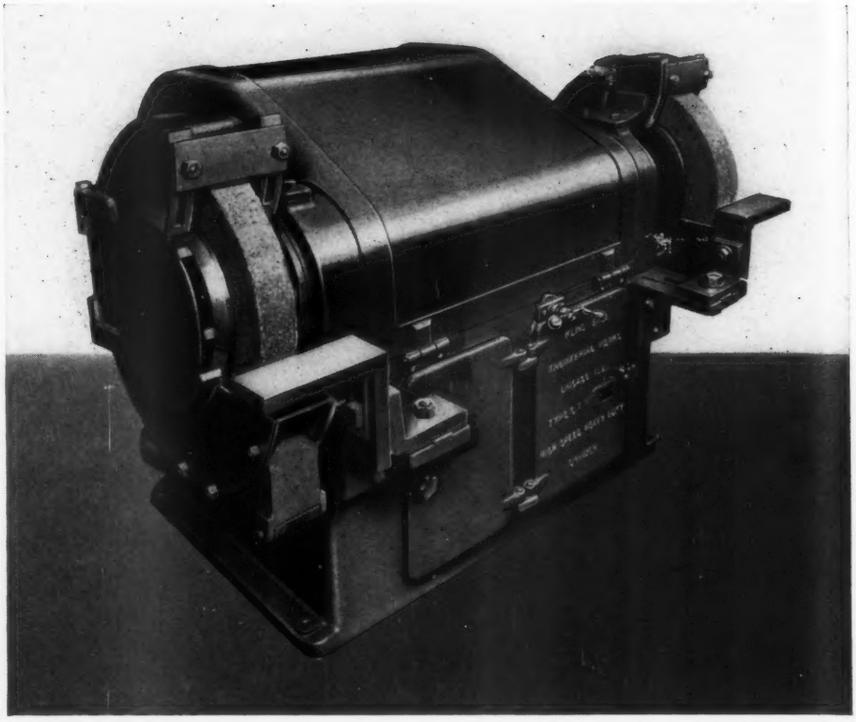
RIPPLE-FLOW FEATURE, incorporated in fin-coil tubing, produces increased turbulence and greater wiping effect of refrigerant, giving higher heat transfer efficiency. Developed by York Ice Machinery Corp., units can be combined into various shapes and sizes as illustrated below, to suit individual installation requirements. With exception of copper tubing all parts are aluminum and therefore do not need external finishing.



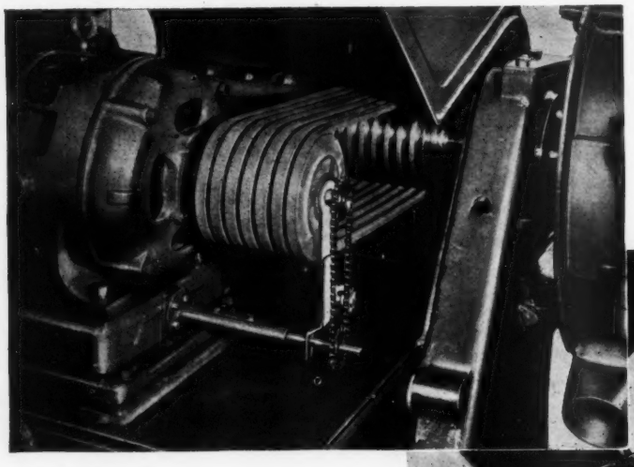
MODERN DESIGNS

Interlocking of Automatic Motor Base Prevents Excessive Grinder Speed

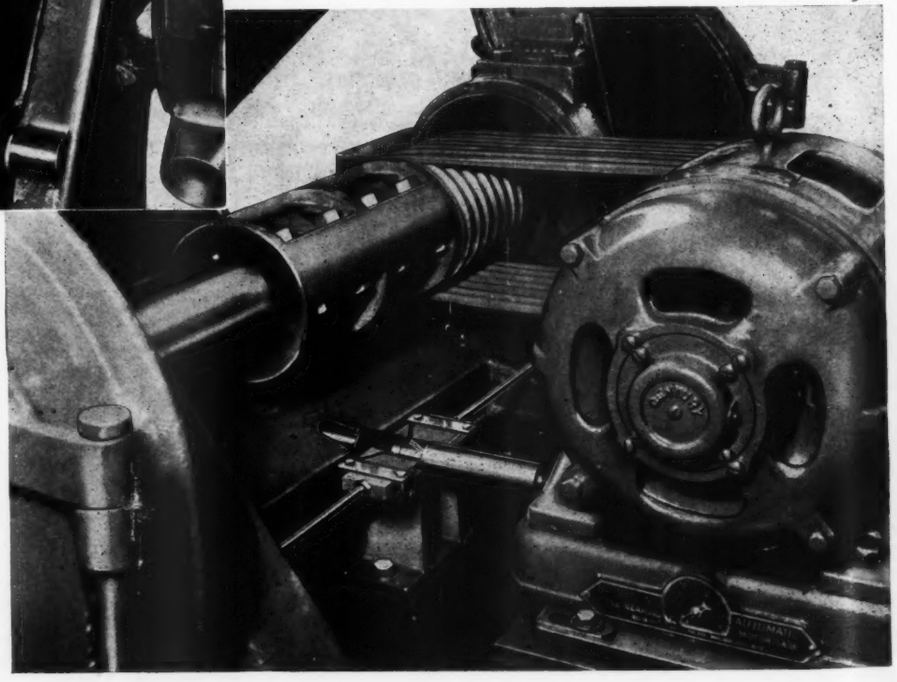
Ingenious "Wheel-Wear Compensator," incorporated in new grinder built by Kling Bros. Engineering Works, utilizes wedge action to permit increased speeds only as wheels wear down to diameter at which higher speed will be safe.



CONVENIENT HANDCRANK on front of grinder (right) controls speed, the interlock with the spark guards being arranged so that a peripheral wheel speed of approximately 8,500 ft. per min. can be reached but not exceeded. Visible at rear of right-hand spark guard is part of the bellcrank-and-lever linkage that interlocks guards with the wheel-wear compensator.



AUTOMATIC MOTOR BASE (left) affords variable spindle speed although motor runs at substantially constant speed. When handcrank is turned, motor is moved forward or backward and pitch diameter of vari-pitch V-belt sheave on motor is increased or decreased proportionally. Thus, when the motor is moved toward the spindle shaft, the pitch diameter of the motor sheave is increased and the spindle speed is correspondingly increased. In this view, bellcrank portion of interlock linkage is below right spindle bearing.

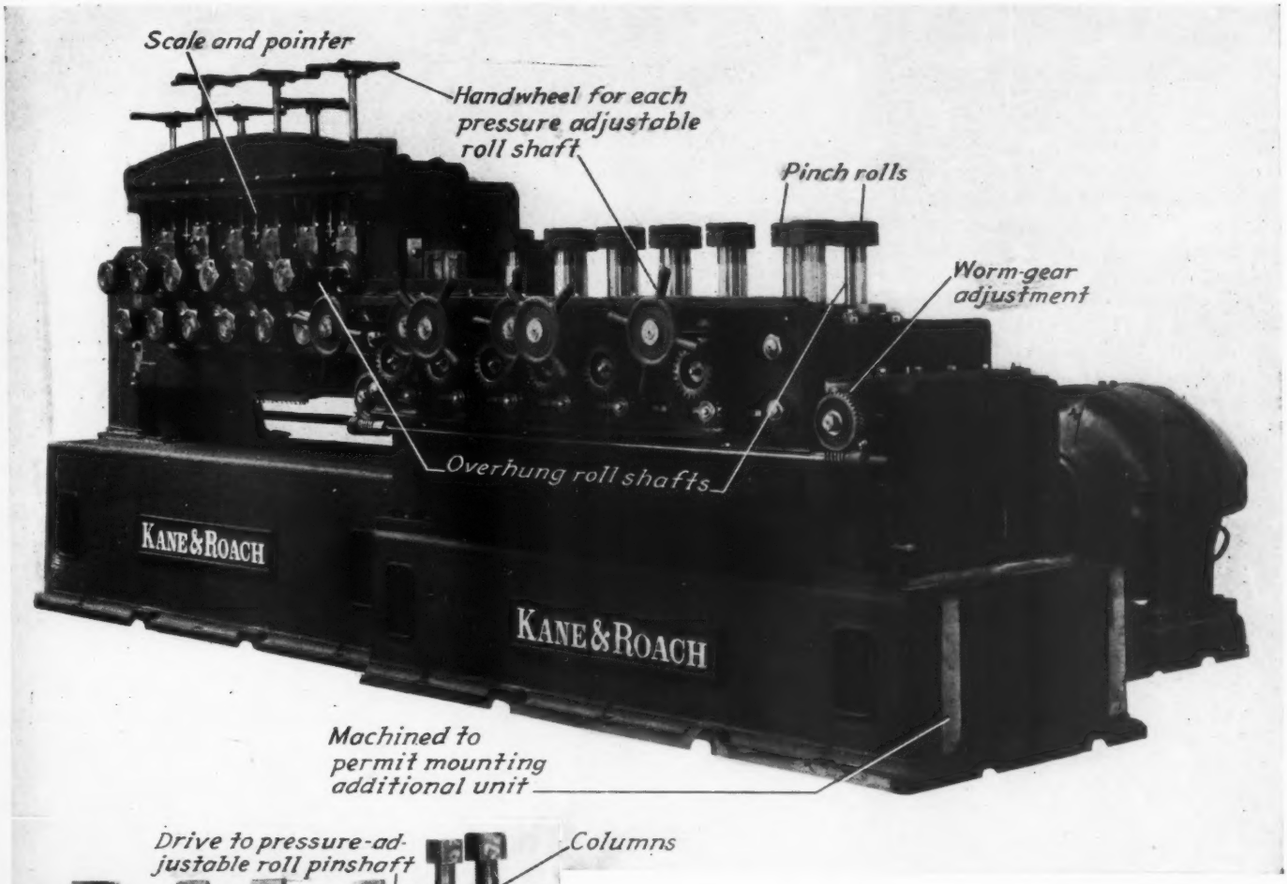


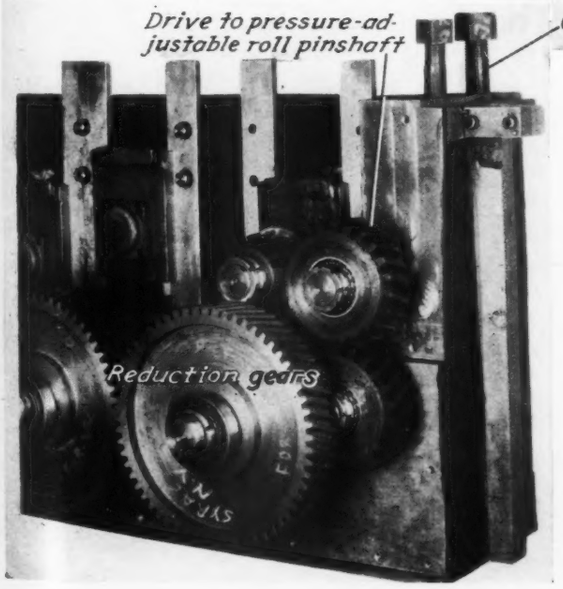
WHEEL-WEAR COMPENSATOR (right) consists of a double wedge mounted on a worm wheel, and two matching wedges each connected to a spark guard by a bellcrank-and-lever linkage. When handcrank is turned to increase speed, worm nut carries double wedge toward motor until stopped by a matching wedge. The matching wedges are moved outward by interlock linkage when the spark guard is lowered upon decrease in wheel diameter through wear. Gap thus left permits double wedge to be moved toward motor, thus permitting increase in spindle speed.

MODERN DESIGNS

Straightening-Roll Features Show Trends in Larger Machines

Design of Kane & Roach machines for edge and flat rolling of metal stock provides for either overhung shafts or outboard bearings, means for adjusting roll pressure and position. Bearings are sealed, and motors usually variable-speed type



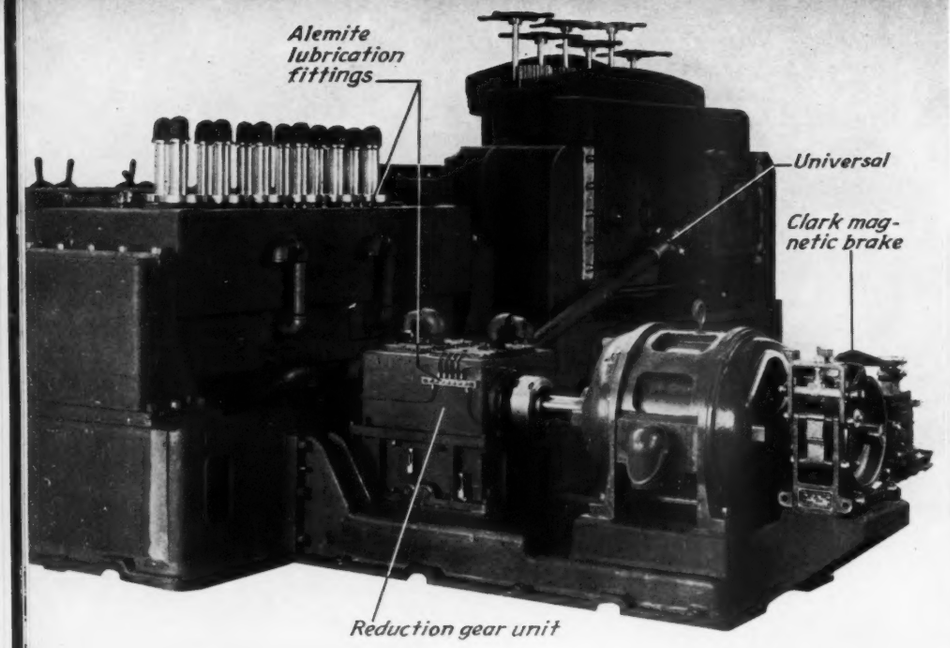


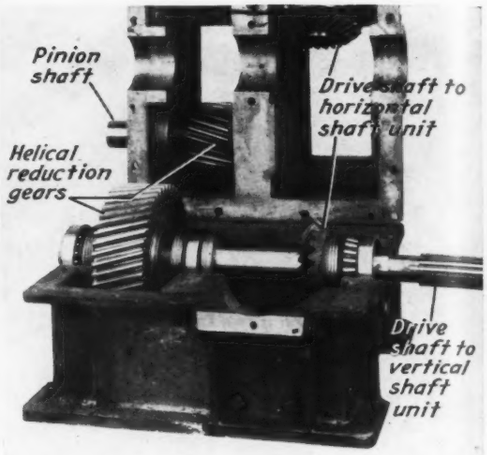
OVERHUNG ROLL SHAFTS afford quick interchangeability of rolls in this No. 2A, 24-roll combination vertical and horizontal straightening roll, Type A. Vertical shaft unit is adjustable in horizontal plane and horizontal shaft unit in vertical plane, thereby permitting quick alignment and roll passes from the vertical to the horizontal shaft unit.

All slides have adjusting screw, and pinch rolls at feed end are spring pre-loaded with both shafts power driven. Straight-tooth spur gear drive to pressure adjustable shaft permits generous range of in and out adjustment of vertical shaft unit. Scale and pointer show setting of all pressure adjustable roll shafts. Similar means for recording unit adjustment of vertical shaft unit and vertical adjustment of horizontal shaft unit are provided.

Heat-treated alloy steel columns (Insert) secure the top plate of straightening unit frame to main frame. Extended end of roll shafts carrying the large reduction gears are mounted in anti-friction outboard bearings.

MODERN DESIGNS





DRIVE TO HORIZONTAL SHAFT is through universal joint with splined connection, in this 24-roll vertical and horizontal straightening roll (above, rear view). Though a different machine, it is similar in general design to unit shown on proceeding page. Alemite lubrication system has unit headers at convenient points. All gears are inclosed and run in oil-tight casing. Anti-friction bearings throughout. A stop bar (not shown) shuts off main drive motor and throws on the magnetic brake should the operator get caught by stock.

The primary drive reduction gear shown in the insert has main shaft mounted in anti-friction bearings with internal grease seals of the Alemite groove type and external seals of the Chicago Rawhide type.

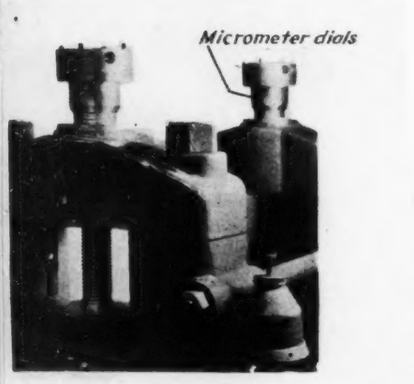
External seals are also provided for the pinion drive shaft and for the horizontal unit drive shaft.

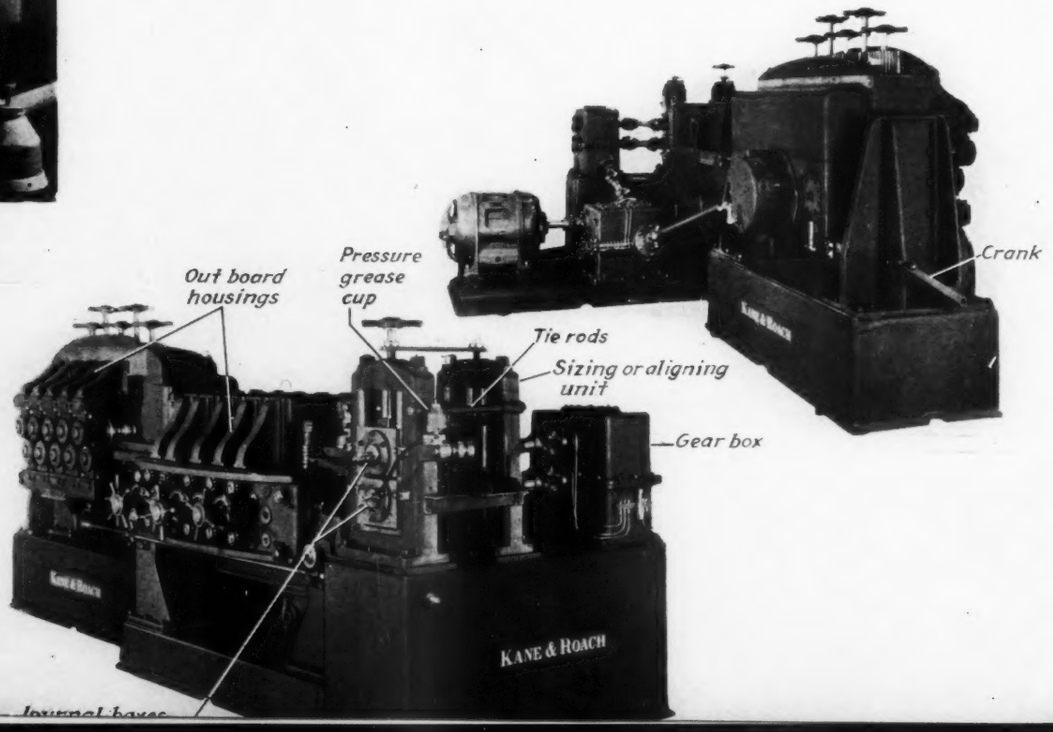
OUTBOARD BEARINGS greatly increase capacity of machine and reduce load and wear on main frame bearings, in this No. 1A, 20-roll combination vertical and horizontal straightening roll (below), Type A, with No. 1A sizing or aligning mill. Mill drive is by universals from separate gear box unit.

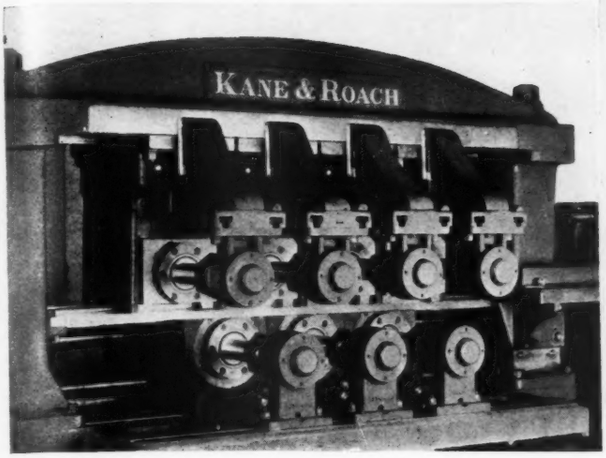
Top and bottom journals of sizing unit are provided with vertical adjustment. Top plates of sizing unit are detachable, permitting quick removal of both top and bottom roll shafts complete with journal box so that if desired rolls can be ground on the roll shafts. In addition to four heat-treated alloy steel column bolts, which secure the top plates to the main frame and extend full length through the housing, thereby relieving tension in the housing, additional rigidity is provided by tie rods. Lubrication is by means of continuous pressure grease cups, grease being forced continuously through the idler rolls thereby excluding scale dust.

Vertical shaft straightening unit is provided with crosswise adjustment and vertical adjustment of the horizontal unit is obtained by means of the crank.

As shown in the insert, micrometer dials can be installed on the sizing unit to facilitate setting of the rolls.







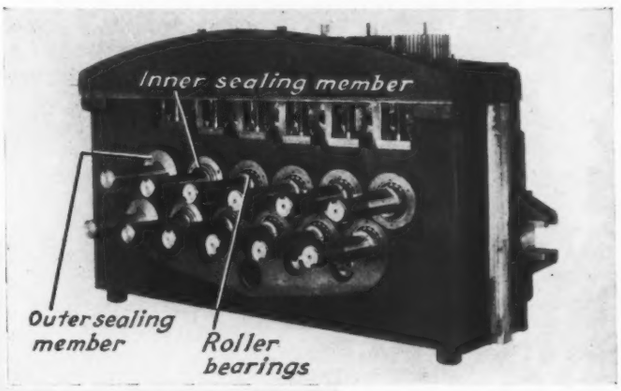
MULTI-PASS ROLLS are employed in the horizontal shaft unit of this No. DD 24-roll combination vertical and horizontal straightening roll (below), Type A. It is equipped with one set of rolls which can handle a range of rectangular, channel and tee sections. Edge straightening is done in the vertical shaft unit, with adjustable-type rolls capable of handling the range of sections mentioned.

The assembled vertical shaft unit is shown in the insert, photographed before mounting, with shafts horizontal. Gear-driven adjusting screws, for varying roll pressure, are clearly visible. Also shown is the method employed to prevent scale from entering the shaft roller bearings. Inner and outer sealing members are used, the outer member also acting as a slinger. Because a considerable amount of scale is removed during straightening, openings are provided in the frame so that the scale can fall through onto the main base and be readily removed.

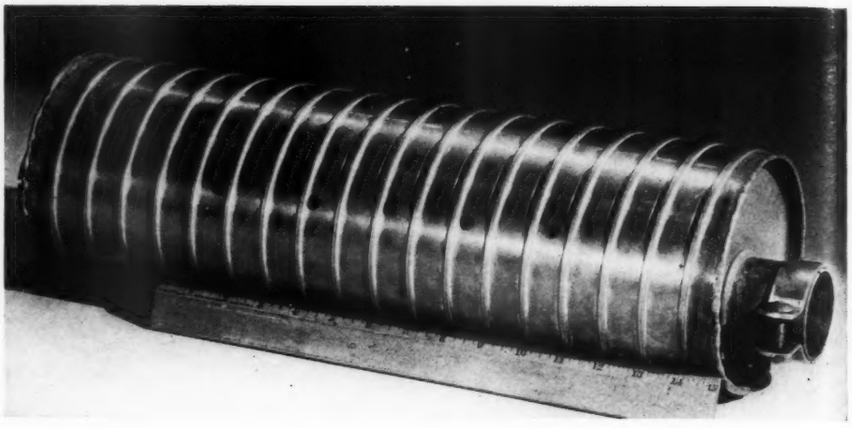
Although this machine and those shown at the top of the two preceding pages are provided with overhung shafts, the designs are such that all could be equipped with outboard housings. All machines are arranged for motor drive with the motor direct-connected to the initial gear box. In general, variable-speed motors are used, affording higher speeds on lighter sections and slower speeds on heavier sections.

THIS 2B 15-ROLL COMBINATION vertical and horizontal straightening roll (above), Type B, incorporates all major features employed in the Type A machines but differs primarily in that all shafts can be adjusted lengthwise with respect to the stock.

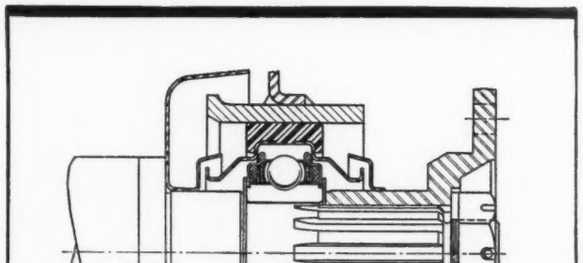
Because spreading of the centers is possible, the range and capacity of the machine are increased. On a machine of a given size, for example, if the centers can be spread, the capacity of the machine can be increased on balanced sections such as squares, hexagons, and rounds. Likewise, in straightening rectangular sections, the capacity of the machine is increased by spreading the centers on the unit in which the edge straightening is being done (thereby preventing excessive upset) and by decreasing the distance between centers on the unit doing the flat straightening.



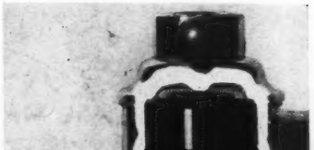
MODERN DESIGNS



LIGHTNESS AND RIGIDITY in the automotive muffler at right result largely from the spiral-tube design. Developed by the Pratt Chuck Industries, Inc., the tubing is manufactured from strip stock and has a smooth inside surface, diameter of which can be held accurate to within 0.005 in. Double-locked seams which fasten edges of strip together are water and air tight.



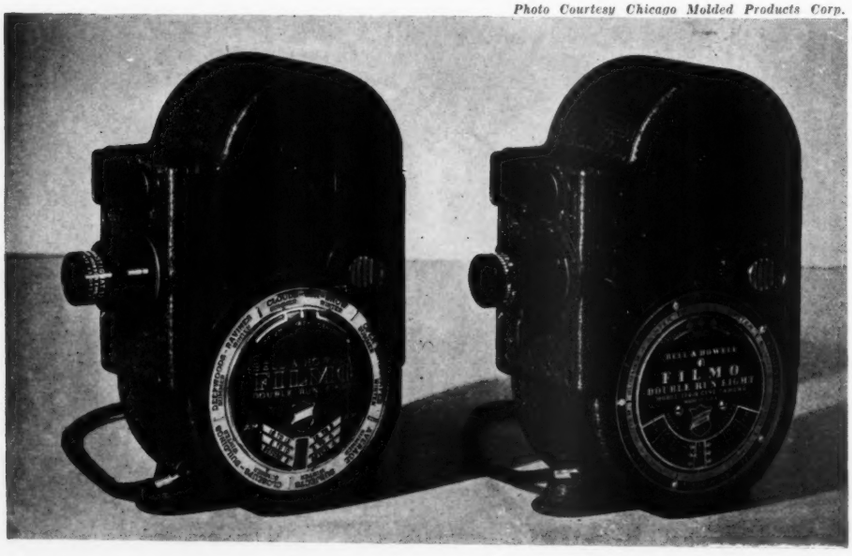
SUB-HOUSING OF RUBBER carries the intermediate supporting bearing (left) used for propellor shafts of both trucks and passenger cars. A New Departure design, it compensates for misalignment caused by weaving or distortion of the vehicle frame.



PLASTIC VALVE PISTON—To avoid chattering and other noises resulting from wear between metal parts, the piston of this toilet flush valve (right), manufactured by the Speakman Company, is made of Durez having special moisture-resistant characteristics.

IT LOOKS SMALLER but actually the new Bell & Howell movie camera (left, below) is same size as original model (right) and is produced from original die-casting dies only slightly altered at little expense. Main alteration in camera is that vertical lines on side panel have been increased in width and decreased in number and have been confined by curved line added to join top and bottom curves. Revised dial for exposure calculator also adds to illusion. Redesigned by Barnes & Reinecke, Chicago, Ill.

Photo Courtesy Chicago Molded Products Corp.



RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

Fabricated of stainless steel by the "Shotweld" method, thirty 16-passenger cable cars will soon go into service for the convenience of skiers and mountain-climbing tourists in the Italian Alps. Each weighs only 660 lb. and is 56 per cent lighter than former type. Builder is Piaggio & Co., of Genoa, Italy, a licensee of the Edward G. Budd Manufacturing Company.

Cellophane windows of generous proportions will also contribute to the light weight of the cable cars mentioned above. According to reports, the material has been found just as serviceable for winter as for summer use—and is probably much less expensive to replace after being punctured.

* * *

Translucent indicating scales of ivory Plaskon feature the newest Multi-pointer gages and boiler meters designed by Bailey Meter Co. The gages are now illuminated and diffusion of light through the scale sharply outlines the graduations for easy reading in dark boiler rooms.

NITRIDING MACHINE PARTS

For Durability and Wear Resistance

Considerations to be observed when designing parts made of steels containing chromium, aluminum and molybdenum to obtain specific physical properties in the core in conjunction with wear resistant surfaces by the ammonia nitriding process

"AFTER HEATING the iron to a slightly glowing temperature, if it be quenched in the urine of a red-haired boy the iron upon cooling will be found to have an extremely hard surface." Such in substance are the directions contained in an old book on the ancient art of alchemy.

Unwittingly, the alchemists had hit upon the nitriding process. But it remained for modern metallurgists to establish the fact that it was the ammonia in the urine together with small amounts of aluminum in the iron that caused the extremely hard skin or case. Nitrogen in the ammonia was liberated by the heat in complex form to combine with aluminum in the iron, resulting in a skin of extremely hard aluminum nitrides on the surface of the iron. In modern nitriding the parts are held for 60 to 100 hr. at a temperature between 850 and 1,200 deg. F. in a closed furnace through which ammonia fumes are flowing.

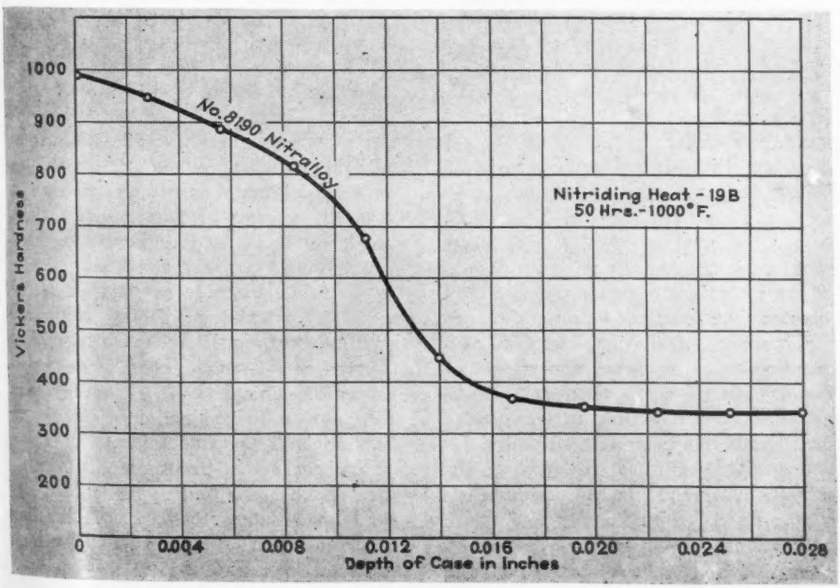
Of recent years further developments in the nitriding process and new alloy steels suitable for nitriding, have been developed. It is now possible to nitride parts of extremely intricate shape. And with a better knowledge of the methods of applying the nitriding process, better results are being obtained. There is no longer any reason for the former complaint that nitriding wearing surfaces flake, and better control of the process gives the designer a greater freedom in applying and specifying nitriding.

Nitriding steels that can be heat-treated prior to nitriding to improve their physical properties, are now available. This enables the designing engineer to specify a heat-treating to obtain the desired physical properties of the core material and then obtain the desired surface hardness by means of the nitriding process.

Perhaps the most frequent reason for failure of nitrided surfaces in the past can be attributed to improper handling of the material prior to the nitriding operation. For example, many engineers expected that the temperature of the nitriding operation would serve to stress relieve the material, thereby taking out previously induced forging, machining or shrinkage strains. However, the nitriding temperature, ranging from 850 deg. F. to 1,200 deg. F., is far too low to have any appreciable effect in strain relieving. Therefore, it should be specified that prior to the nitriding operation the part should be stress annealed at the proper temperature.

Nitriding differs from case hardening in one important respect. Whereas case hardening penetrates to a depth of 1/16 in. or more, the nitrided case penetrates to a depth seldom as much as 1/32 in. Therefore, if the part is to be nitrided it is highly important that the external corners be well rounded and internal corners filleted to prevent the possibility of the nitrided case chipping at these areas. A radius of the order of 1/32 in., merely enough to "break the edge," is usually sufficient.

Fig. 1—Hardness of case at various depths below surface of a typical nitrided part which has been treated for 50 hr. at 1,000 deg. F. in nitriding furnace



Depth of Hardness

Although the outer nitrided case is never more than 1/32 in. thick, it has extreme hardness, as high as 1,000 Vickers as indicated on the accompanying chart, Fig. 1. As shown by the curve, the hardness of the skin is greatest at the surface and decreases for the first few thousandths of an inch below the surface. At a depth of about 0.017 in. the hardness approximately equals that of the un-nitrided alloy.

A microscopic examination of the nitrided surface will reveal that it has a granular structure. It is this characteristic that causes the nitriding to flake when the nitrided surface is subjected to heavy wear or rubbing. However, this granular characteristic is virtually entirely on the surface of the nitrided case. By grinding or honing to a depth of only 0.001 to 0.003 in., obtaining a mirror-like surface, the tendency to flake is removed entirely. Of course, the final surface will not be quite as hard, but as indicated by the curve, grinding off even as much as 0.004 in. does not decrease the surface hardness to an appreciable degree.

Of course, in grinding or honing the nitrided surface, great care must be taken so that the same amount of metal will be removed around the entire circumference. Otherwise the case will be eccentric and therefore the surface hardness will vary, perhaps considerably,

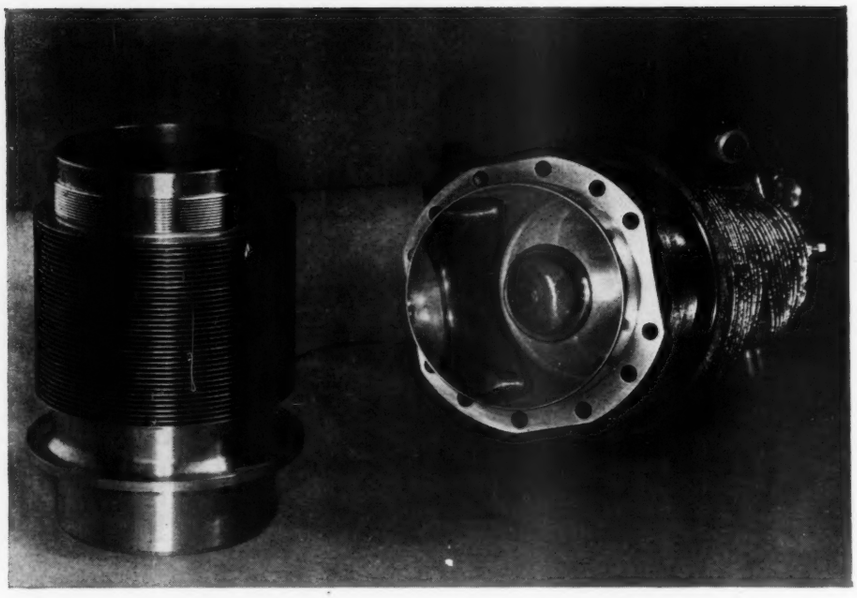


Fig 2—Cylinder barrel for aircraft engine made from a forging heat-treated to obtain physicals and nitrided to resist wear

at different points in the circumference. This precaution does not, however, entail any great difficulties, it merely being necessary that the part be centered on the same axis in both the machining and grinding operations.

There are numerous examples of nitrided surfaces that have been subjected to the severest kind of services and have shown no signs of flaking. For example, nitrided spur gears, valve stems, cams and similar machine elements have been nitrided and serve successfully, also cylinder barrels of aircraft engines (see *P. E.*, August Number "One Decade of Progress").

Together with the extreme hardness of the case, nitrided surfaces have the characteristics of increasing the corrosion resistance of the material. This, of course, does not imply that nitrided surfaces are corrosion resistant in the sense that stainless steel is corrosion resistant. But the resistance to atmospheric corrosion is greatly increased.

Heat-Treat for Core Hardness

With reference to the abrasion resistance of nitrided surfaces, tests on nitrided steel indicate that the surface will not withstand the abrasive action set up by particles moving at high velocity such as sand-blasting.

In many applications such as in gears and cams, the part is subjected to a high compressive stress. For such service, the nitriding steel should first be given a preliminary heat-treatment in order to increase the hardness of the core metal, subsequent to which the part is nitrided. For this purpose, special analyses of nitriding steels should be used. Also, two nitrided gears should not be run in mesh—only one should be nitrided and the other may be case hardened.

One of the greatest advantages of the nitriding process is the low temperature at which the treatment is conducted. Thus, the problem of warpage is greatly reduced. However, parts such as shafts or spindles with long keyways may be deformed slightly during the nitriding process. Similarly, flat pieces that are nitrided only on one side may warp.

Allowance for Growth

Nitriding slightly increases the dimensions of the part, the amount of growth being a variable depending chiefly on the time and temperature of nitriding. However, the growth will be the same under similar conditions and can be determined experimentally for a sample part. The designer can then allow for this growth in specifying the dimensions to which the part is to be finally machined.

Another factor in the growth is that decarburized surfaces will greatly increase the amount of growth. Therefore, such surfaces should be removed before the part is nitrided. However, even under severe conditions the amount of growth amounts to only a few thousandths, but sufficient to seriously affect the hardness of the final surface after grinding to the required dimensions. If the amount of metal that must be removed in the final grinding is several thousandths more than was allowed for, the resultant surface hardness will be correspondingly decreased as indicated by the chart shown here.

Frequently it may be desired to nitride not the whole part, but only certain areas thereof. Those portions of the surface which are not to be nitrided can readily be masked by tin plating, nickel plating, or coating with molten lead. All excess tin or lead should be removed with a wire brush. Since the tin or tin alloy melts at a temperature below that of nitriding, the excess tin or lead, by virtue of surface tension, may spread over surfaces to be nitrided. Care must also be taken when packing the part for nitriding that tin or lead coated surfaces do not come close to surfaces that are to be nitrided. Otherwise the parts might touch and thereby prevent the proper nitriding. In this connection, nickel plating has the advantage over tin or lead coating in that the nickel does not melt at the nitriding heat and therefore there is no possibility of it contaminating surfaces to be nitrided.

When flat pieces are nitrided on only one surface, the part is likely to be bowed in the nitriding operation because of the growth on the nitrided surface. This also applies to shafts with long keyways on one side. However, such distorted parts can readily be straightened without cracking the case if precaution is observed. It should also be pointed out that resistance to both corrosion and fatigue will be materially reduced if the case is cracked.

The hardness of the nitrided surface is independent of the length of time that it was subjected to the ammonia fumes. However, the depth of penetration increases up to a certain point with the length of time that the part is held at the nitriding temperature in the furnace. Usually, the time of nitriding runs from 60 hr. to 100 hr., the latter giving a maximum depth of case of approximately 0.030 in. Beyond 100 hr. in the nitriding furnace has no effect, either on the surface hardness or the depth of the case.

Special Analyses

The particular type of nitriding alloy steel to be selected will depend upon the service to which it is to be subjected. Machining considerations may also be a factor. When free machining is of importance, nitriding steels with a high sulphur content are sometimes used, but this is at the expense of maximum impact properties. Where this is undesirable, there is available a nitriding steel containing selenium, which alloy has exceptional free-machining characteristics without the sacrifice of impact strength. This alloy is commonly used for parts produced on automatic screw machines for machineability.

For gears that are required to withstand both static and dynamic loads, as well as resisting tooth wear, nitriding steels that can be heat-treated to a high core hardness are available.

Malleable Iron Castings

Properties and Importance in Engineering Construction

DR. ENRIQUE TOUCEDA
Consulting Metallurgical Engineer

The author is also director of the central testing laboratory maintained by the Malleable Founders' Society for conducting research and to serve foundries to the end that the mechanical properties of malleable iron may be of a uniformly high standard

TWENTY YEARS of organized research activities have established many facts, of interest to designing engineers, which show that malleable iron is a unique material and as made in present day practice has many features which make it a metal of great importance in engineering construction.

Designers no longer hold the idea that malleable iron is a superior kind of cast iron. The term "malleable iron" does not apply to a group of materials with different analyses and characteristics as does the term "cast iron." Malleable iron has a fairly specific chemical composition and a uniform structural composition. Regardless of its strength, cast iron is brittle but malleable iron is tough. There is no similarity whatever between these two products in mechanical properties, in chemical or structural composition. They are as dissimilar as two metals possibly could be.

A short review of the manufacture of malleable iron will help those designers, who are not familiar with the subject, to better understand the properties of the metal which have made it so generally acceptable by engineers. The process of making malleable iron is conducted in two steps. First, a mold is made from a pattern and a casting is made of the part desired from a suitable mixture melted in an air, electric, or cupola furnace, the resultant product being free from any carbon in the form of graphite. All carbon in the metal should be present in the combined form, otherwise the annealed castings will be of inferior quality. The metal as cast is comparatively low in carbon and high in silicon, but in no case is the silicon sufficiently high to prevent the union of the carbon with the iron. Secondly, through a heat-treating cycle, these hard and brittle white iron castings are converted into a soft, ductile and tough product in which all the carbon is present as free temper carbon nodules. This is the second step in the process and is known as the malleableizing or graphitization operation.

Fig. 1—Malleable iron wedge before and after testing; 30 blows of the 21-lb. hammer with free drop of 46 in. failed to develop any fracture

To be suitable for graphitization a white iron has but two elemental constituents; these are relatively soft pure iron and extremely hard carbide of iron. A part of the latter is mechanically mixed with the pure iron in the form of pearlite. When the hard iron castings are heated to a suitable temperature above the critical, the austenite derived from the pearlite and some dissolved carbide gradually are broken up into soft iron and temper carbon, that is, graphitization takes place. By increasing and maintaining the temperature to about 1550 to 1600 deg. F., carbon is absorbed from the carbide of iron present, some of which is precipitated in the form of "temper" carbon and the remainder stays in an indefinite solution with the iron. To effect complete precipitation and to prevent reversion to hard carbide of iron when cooling through the critical temperature, a very slow rate of cooling must be maintained down to about 1275 deg. F. This method of manufacture produces a metal that is a mixture of pure iron, free carbon or graphite in the form of "temper" carbon, silicon, manganese, phosphorus and sulphur.

During the malleableizing process some carbon is slowly eliminated from the surface of the casting which is directly exposed to the oxidizing atmosphere of the oven this results in a decarburized surface or "skin," as happens when steel or any ferrous metal is heated to redness in contact with air.

The notion that the strength of a malleable iron casting is imparted to it because of the decarburized surface metal or "skin" is not substantiated by test data. Decarburization at the surface does help strength and ductility, yet much test data shows that the tensile strength and elongation of malleable iron test bars are not seriously affected by the removal of the surface metal.

Malleable iron castings because of their strength, ductility, shock and corrosion-resistance properties, smooth finish and especially the ease with which they can be machined are of much importance in automotive construction. The field of industrial applications

Fig. 2—Gear wheel and worm of intricate design for a railway car power-brake, an example of a malleable iron part that is put in service without any machining

where the same considerations are important is large, with the result that designers are specifying malleable iron parts for agricultural implements, engines, conveyor and elevator equipment, electrical and industrial power equipment, household appliances, machine tools and special machinery.

Designers in these and other fields of industrial development and product engineering are taking advantage of the improved uniform qualities of malleable iron to greatly strengthen their products to withstand impact, shock and fatigue.

When using malleable iron, because of its uniform structural composition the engineer need introduce into his calculations very little extra for safety to offset the "factor of ignorance" generally used as a safeguard against metal being unsound because of the presence of blow holes, or to make allowance for load carrying sections in time being greatly reduced through corrosion.

In connection with hidden defects there are numerous items to consider. Shrink is just as liable to be present in one metal as in another, since this is practically a molding problem. This statement is not true in the case of blow holes or non-metallic impurities, which rarely are present in malleable iron.

Then again, in the engineer's choice of materials there is the important question of how a metal will act when subjected to occasional very severe overloads, a situation where a high yield point and toughness are essential properties. Ordinarily, toughness is measured by the area under the complete stress-strain diagram for the material. However, in malleable iron and some other metals, there exists an undefinable something, possibly superior cohesive properties, that may account for its toughness in service under impact, which certainly would not be disclosed by the size of the area under the stress-strain diagram.

As an index of how a material will stand up under impact, the value of the notch bar impact test has been questioned by many competent engineers, and correctly so, for just the part played by the notch is problematic. This does not mean that every kind of an impact test is of no import, but it does mean that the stress concentration incident to a notch should be avoided, as obtains with the specimen used for the making of impact tests of malleable iron. Here a wedge in the "as cast and annealed" condition six inches long and one inch wide is used. It is one-half inch thick at the large, and one-sixteenth inch thick at the thin end. This wedge is held upright under the tup of an impact machine and a 21-lb. weight is allowed to fall on the thin end through a distance of 3.33 ft. causing the wedge to curl. The average number of blows before failure exceeds 20, and many wedges do not fail at 30 blows. No notch is introduced and a true measure of the ability of the metal to stand up under impact is secured.

The excellent rust-resistant properties of malleable iron as compared with other ferrous products are well known from observations of castings that have been in service many years, such as fences made of steel tubes with malleable iron fittings and tie plates in railroad track service.

In Table I are given values for the average mechanical, electrical and magnetic properties of malleable iron, with a few physical constants. As in steel, the mechanical properties of malleable iron vary with the thickness of the sec-

TABLE I—MALLEABLE IRON

Average Mechanical Properties

Tensile strength, lb. sq. in.	54,000
Yield point in tension, lb. sq. in.	36,000
Elongation in 2 in.	18 per cent
Reduction in area (see Note 1)	19 per cent
Modulus of Elasticity in Tension, lb. sq. in.	25,000,000
Compressive strength (see Note 2)	
Ultimate shearing strength, lb. sq. in. (see Note 3)	48,000
Yield point in shear, lb. sq. in.	23,000
Modulus of elasticity in shear, lb. sq. in.	12,500,000
Yield point in torsion, lb. sq. in.	24,000
Modulus of rupture in torsion, lb. sq. in.	58,000
Brinell hardness number	100–140
Charpy Impact Value, ft. lb. (see Note 4)	16.5
Wedge test for impact (see Note 4)	
Fatigue Endurance Limit, lb. sq. in (No worth while data, probably about 25,000 to 26,000)	
Effect of temperature (see Note 5)	

Physical Constants

Specific gravity	7.15 to 7.45
Shrinkage allowance, in. per ft.	1/8 to 3/16
Coefficient of thermal expansion per deg. F.	0.0000066
Specific heat, c.g.s. units	0.122

Electrical and Magnetic Properties

Resistivity, microhms per c.c.	28 to 37
Magnetization properties (see Note 6)	
Magnetic hysteresis (see Note 6)	

NOTES FOR TABLE I

1. Reduction of Area. *The elongation usually is spread quite evenly over the entire gage length, instead of being restricted locally. This may be construed to mean that cohesion is more uniform in malleable iron than in other ferrous metals.*

2. Compressive Strength. *In the case of ductile ferrous metals the yield point in compression so closely approximates the same property in tension, that the latter, being much more easily determined, obviates the necessity of making the former. Also, it is impractical to determine the compressive strength of such products, because once the yield point has been passed the specimen flattens out yielding no well marked fracture.*

3. Shear and Torsion Tests. *In determining shear by the "direct method," approximate results only can be secured because a certain amount of distortion caused by the combined effect of compression and bending during the test can not be avoided. Consequently, shearing properties are better studied from torsion tests. The number of twists per foot of length will furnish an estimate of the toughness of the material, and their distribution yields some indication of the variation in hardness which tends to cause an uneven localization of the twists, there being less distortion at planes of greater hardness.*

4. The wedge test *will furnish a more accurate idea of what can be expected of castings that are to be subjected to shock and occasional overload in service than a notched bar test, where the stresses are concentrated at the root of the notch.*

5. Effect of temperature. *If malleable iron is heated to a temperature in excess of its critical range, the temper carbon will start to revert back to the combined form, and if heated to around 1600 deg. F. practically all of it will be reverted. Malleable iron can be heated to around 800 deg. F. without loss in tensile properties.*

6. Magnetization Properties. *When high permeability is required in iron the carbon should be in the form of temper carbon, while combined carbon or free cemenite should be absent. Malleable iron possesses high induction and permeability and low hysteresis loss.*

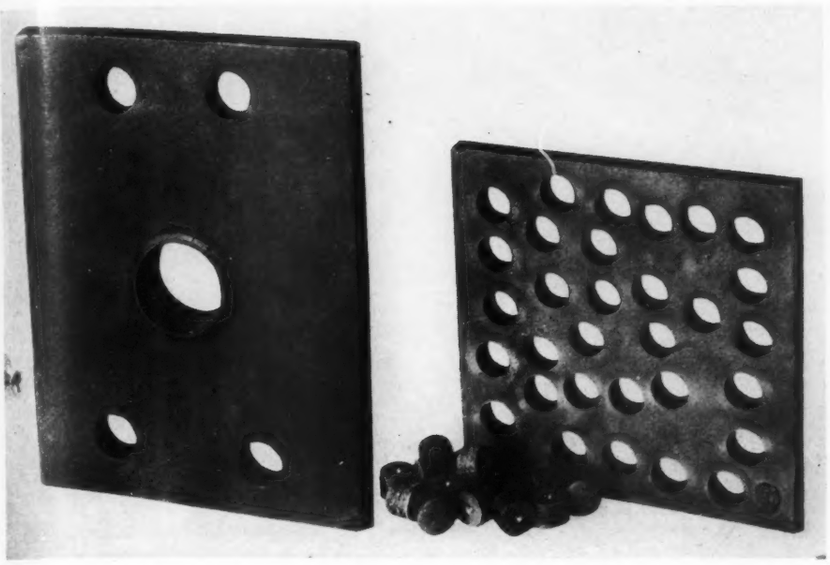


Fig. 3—Malleable iron can readily be punched. At right is 5/8 in. thick cast plate in which 3/4 in. holes have been cold punched with no sign of fracture in the metal structure. The casting on the left had five 3/4 in. holes punched in it and the center hole was then drifted to 1 1/2 in. diam. without sign of fracture in the upset metal

tion, the tensile strength approximately decreases with increasing diameter of the section by an amount proportional to the cube of the diameter. Elongation approximately decreases with increasing diameter of section by an amount proportional to the 5/2 power of the diameter.

Being extremely ductile, malleable iron can be punched without trouble. A 3/4 in. hole in a 5/8 in. plate can be enlarged by drifting to 1 1/2 in. without developing incipient cracks. It seldom fails under either compression or transverse loading. In compression the material flows indefinitely and in cross-bending it deforms to an extent which renders the part useless in service before fracturing. The material takes a permanent set of 1 per cent at about 28,000 lb. per sq. in. in compression Castings can be straightened in presses to correct warpage caused by uneven packing when annealing. Some parts used in the automotive industry have their flanges coined to a uniform thickness. Malleable iron parts are frequently fastened by riveting to other parts.

Ordinarily, castings rarely are designed with sections that exceed one inch. The average section used is about 5/8 in. This does not mean that a section 3 in. square could not be thoroughly malleableized. Where accurate alignment and absence of deflection are essential factors, dependence is placed on a distribution of the metal that will favor these properties, which coincidentally tends to safeguard lightness as well as stiffness.

When designing malleable iron castings the designer should be guided by the same principles that apply to the design of good steel castings. Every effort should be made to stimulate cooperation between designer, manufacturer and foundry, for such cooperation will promote production of castings of the greatest soundness and other physical properties at the least cost.

In regard to machineability it is well acknowledged by those working on a production basis that there is no ferrous product of equal tensile properties that can be machined with equal speed and tool life, which accounts in part for the fact that 56 per cent of the product of the industry is used by the automobile and tractor companies.

Threading and other machining operations performed in the extensive pipe fitting industry are run at high speed. To obtain the desired machining speeds, also smooth, accurate threads and surfaces, the manufacturers intentionally use a higher carbon malleable iron generally made by the cupola process and sacrifice some ductility and strength.

Malleable iron cannot be successfully welded because at a welding temperature the temper carbon will revert to the combined form. For the same reason the use of malleable iron at temperatures over 1200 to 1300 deg. F. should be avoided.

However, malleable iron can be successfully brazed if suitable welding rods are used; either a Tobin or manganese bronze rod should be used. The surfaces to be brazed should be cleaned thoroughly and tightly fitted together prior to the operation of brazing.

Fig. 4—A malleable iron rear-axle housing—rigid enough to keep the driving mechanism in alignment, strong enough to support the brakes and springs, and tough enough to withstand the shocks of heavy truck service

Fig. 5—Armature spider casting of malleable iron for mine electric locomotive motor. It weighs 342 lb.

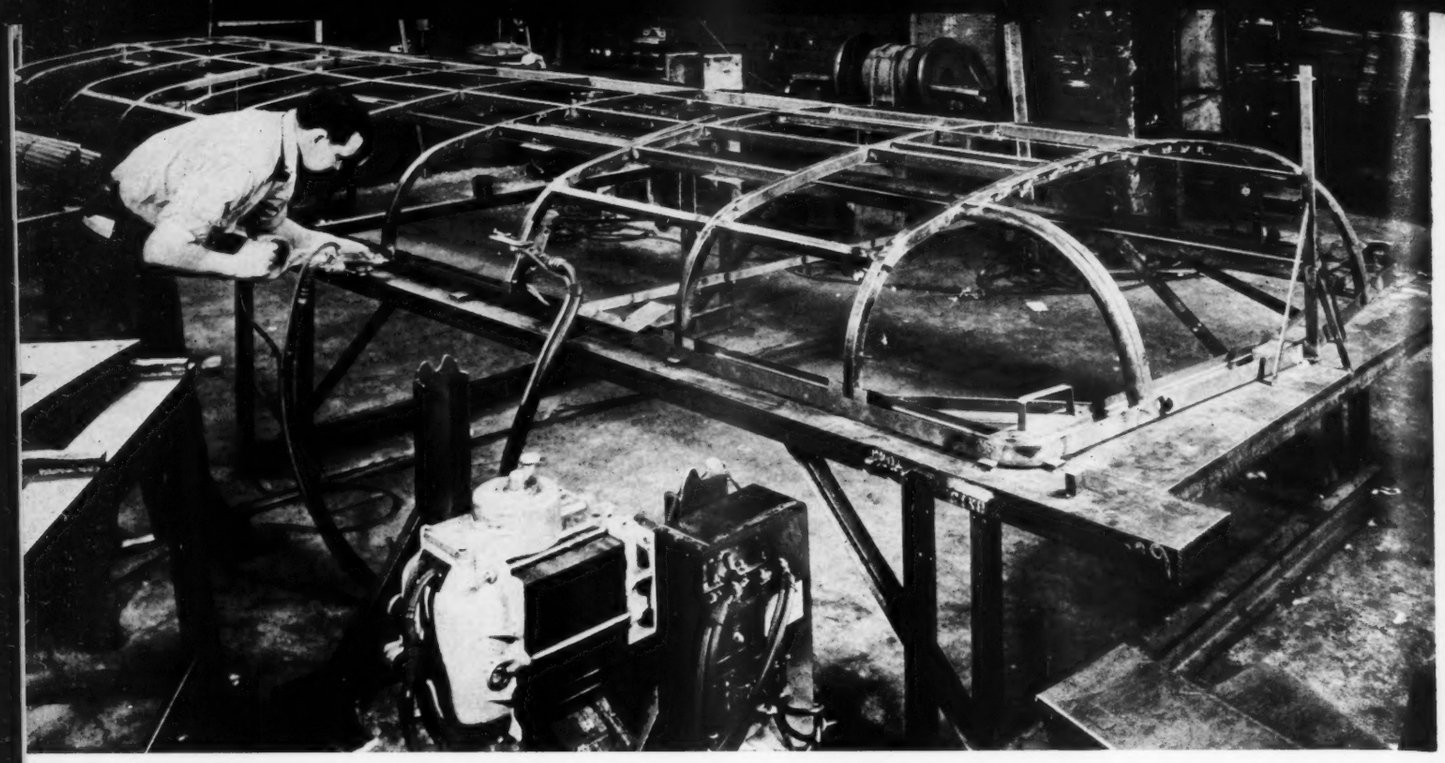


Fig. 1—Indirect spot welder used in fabrication of tubular bus top

STEEL TUBE JOINTS

Possible With Improved Fabricating Technique

Methods for joining tubing to other structural members with illustrations of typical fastening operations and devices based on data furnished by the engineers of Steel and Tubes, Inc.

WHEN USING TUBING it is often necessary that it be bent to a required shape prior to its assembly as a component part of a frame. Modern tools have changed tube bending from a complicated procedure to a fairly exact operation. Manufacturers and fabricators are now making efforts to educate the users so that impractical designs will be eliminated, because lack of basic information concerning the proper design of a part where bending is required, often makes it difficult for the manufacturer to supply the part without excessive expense and trouble.

There are a few general observations which if noted can be helpful in laying out finished parts. In making a bend, the outside metal of the tube at the bend is stretched, and the inside is shortened so that the tube tends to buckle with consequent formation of ripples on the inside of the bend. For light gages it is therefore necessary to use a mandrel to keep the metal smooth. The minimum radius of bend that can be made is dependent upon the cross section, gage and temper of the metal. As a guide, minimum radii for mandrel bends for various diameters and gages of round tubing are given in Table I. The radii listed therein are for the centerline.

The equipment used for making a bend with a mandrel consists of a machine to which is attached a bending die and mandrel holder and the necessary jaws and clamps to grip the tube while being bent. The tube is either mechanically pushed over the mandrel or the mandrel is inserted into the tube. The best grade of bends is made by this process. The reduction in diameter is very slight and the bend free from wrinkles. But, since the tools are expensive and the operations slow, the cost is often high. This method need be used, however, only for making bends when the metal must be kept smooth. In light gages and for small radii it is difficult to make bends of this type that are entirely free from wrinkle "shadows" so that the data given in the table of minimum radii should not be diminished in general practice.

The tools required in making a bend without a mandrel are inexpensive, can be used over a wide range of angles and the operation of bending is rapid. To support the metal and to keep it from wrinkling, the dies have to be somewhat smaller than the tube, so that there is a resulting reduction in diameter. The minimum radii for satisfactory bends without a mandrel are determined by the following formula:

$$L = \frac{0.2468\ \pi\ (D^2 - d^2)}{G}$$

L = Centre line radius in inches
D = Outside diameter in inches
d = Inside diameter in inches
G = Wall thickness in inches

In the bending and fabricating of square and rectangular tubes, it is impossible to work according to any rule of thumb because of the infinite number of combinations of dimensions. Expert advice can, however, be obtained from the manufacturers, and it is recommended that this advice be sought before undertaking any bending operations, no matter how simple, on any tubing other than round.

In a tubular frame assembly, after the tubing has been bent to the required shape, the next step is the joining of the tubes together. Oxyacetylene or electric arc welding is often used because of the low initial cost of equipment. Of these two methods, oxyacetylene weld-

Fig. 2—Self-tapping screw used in attaching bus side sheets

ing is advisable when material of 18 B.W. gage or lighter is used. It is also to be favored in some applications where 16 gage material is used. In wall thicknesses heavier than 16 gage, arc welding is equally satisfactory. Resistance welding and flash welding involve a greater expenditure for the necessary equipment but it is found to be economical where there is any sizeable production of joints of any one type.

Joining Sheets to Tubes

In the joining of sheets to tubular members, a spot welder can frequently be used to advantage. Several methods have been used successfully in production. In one, a strip about 2 inches wider than the side of the tube to which it is to be fastened may be spot welded to the tube and then the sheet applied to this strip by means of ordinary rivets. Another method is to spot weld the sheets directly on to the tube, using either a pointed electrode or flat electrode. The flat electrode requires a greater current and a shorter time interval, and has the advantage that considerably less marring of the surface of the sheets occurs. The other electrode is placed on the outside of the tube at the side opposite the sheet. Fig. 1 shows the fabrication of a tubular bus top, in which an indirect welder is used. In this, one electrode is clamped to the unit within 10 feet of the point where the weld is to be made, and the weld is then made by a single electrode gun. It is said that this method works very satisfactorily on light gage sheets, also in many places where it is almost impossible to do the work by any other method.

A commoner method for welding sheets directly to tubes is to use a portable, two-electrode pressure gun, as is shown on the floor in Fig. 3; or if the unit is not too large to be handled conveniently, it may be welded in a press welder of the type shown in the same figure.

Self-tapping screws are frequently used to attach sheets to tubes. Where these are used it is only necessary to drill holes in the material at the joint, the insertion of the screw cutting its own thread. Fig. 2 illustrates the use of self-tapping screws in the attachment of side sheets to a bus frame. Ordinarily, one does not think of a self-tapping screw as a means of joining structural members, but there are quite a number of transportation vehicles which have been in service for a number of years now which are of the true stressed-skin type, in which the skin is attached by screws. In addition, considerable laboratory work has been done on built-up structural members made by screws of this type, and both vibration and destruction tests on these built-up members have shown the screws to be a very effective means of attachment.

A particularly interesting type of drive screw construction is shown in Fig. 4. In this construction the drive screws, which are hardened, pointed Type 21 Parker-Kalon screws, are placed in a hopper in a machine devised for this purpose, and are driven through the material to be attached to the tube and the wall of the tube without drilling or punching holes initially. This type of construction has been used very successfully in the fabrication of automobile seat frames where a fiber material is nailed directly on to the tube. Fig. 4 shows one of these special machines in operation, attaching fiber board to a seat frame, and the insert in this photograph shows in actual size a cross section of one of these tubes with a drive screw through it, and the drive screw. The inward extrusion of metal and the large pitch of the screw may be seen clearly. This is a very recent development but it would seem that it provides a method of fabrication which should make tubing economically possible in many structures where before it was out of the question from the standpoint of cost.

Still another method of attaching a sheet to a tube is shown in Fig. 5, which illustrates the Huck rivet made by the Clark Equipment Company of Buchanan, Michigan, which may be driven with a special gun from one side, thus avoiding the necessity for getting into the inside of the tube. The line drawing at the left hand side of Fig. 5 shows a cross section of this rivet extended for inserting in the hole and also a section of the rivet and sheet after driving.

As the rivet gun is applied to the rivet, its jaws automatically engage the rivet pin pull grooves. When the trigger is depressed, oil supplied by a pressure generator moves the jaws away from the work and pulls the pin

TABLE I — MINIMUM RADII FOR MANDREL BENDS

O.D.	*B.W. Gage*	*Minimum Radius*
½ to ⅞	16	1½ x O.D.
½ to ⅞	18	2 x O.D.
½ to ⅞	20	2½ x O.D.
1 to 2¼	14	1½ x O.D.
1 to 2¼	16	2 x O.D.
1 to 2¼	18	2½ x O.D.
1 to 2¼	20	3 x O.D.
2½ to 3¼	14	2 x O.D.
2½ to 3¼	16	2½ x O.D.
2½ to 3¼	18	3 x O.D.
2½	20	3½ x O.D.
3½ to 4	14	3½ x O.D.
3½ to 4	16	4 x O.D.
3½	18	4½ x O.D.

Reduction in diameter of the vertical plane 120 per cent of the gage-maximum.

Fig. 3—Tube controlled press welder making gusset plate joint, portable gun for similar work in foreground

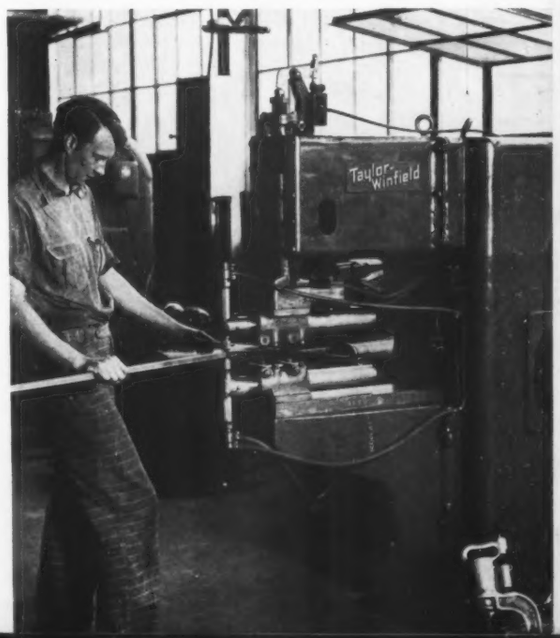


Fig. 4—Attaching fiber board to tubular automobile seat frame by means of drive screws with special rivet setting machine. Insert shows screw and cross-section of tube

(A) through the sleeve (B), The reaction to this force is taken by the anvil end of the gun, against which the rivet head rests. As the pin is drawn through the sleeve the clearance between the rivet and the hole in which it has been inserted is filled by the action of the extruding angle (2) of the pin passing through the small hole (3) in the rivet between its ends. When the head (4) of the pin engages the dished washer (C) it flattens out the latter, thus increasing the bearing area against the tubular part of the rivet. Further travel of the pin causes this tubular end to form a head on the blind side of the work, which pulls the parts together. As the pull on the pin continues, the anvil of the gun is forced over the rivet head (5), driving the material into the rivet pin locking grooves (6), which are now within the rivet head, thus locking the pin in the sleeve. The pull on the pin then continues until the pin is broken off at the groove (7), the broken part being ejected through the gun. This entire cycle is silent and requires but a fraction of a second. This rivet has been used in production on railway car equipment and automobile chassis frames very successfully and has demonstrated both in test and service that it has materially greater holding power than the usual hot or cold driven rivet. The rivets themselves are considerably more expensive than the conventional rivet, but the speed with which they are driven and the fact that but one man is needed to do this in many structures more than makes up for the additional cost of the rivet itself.

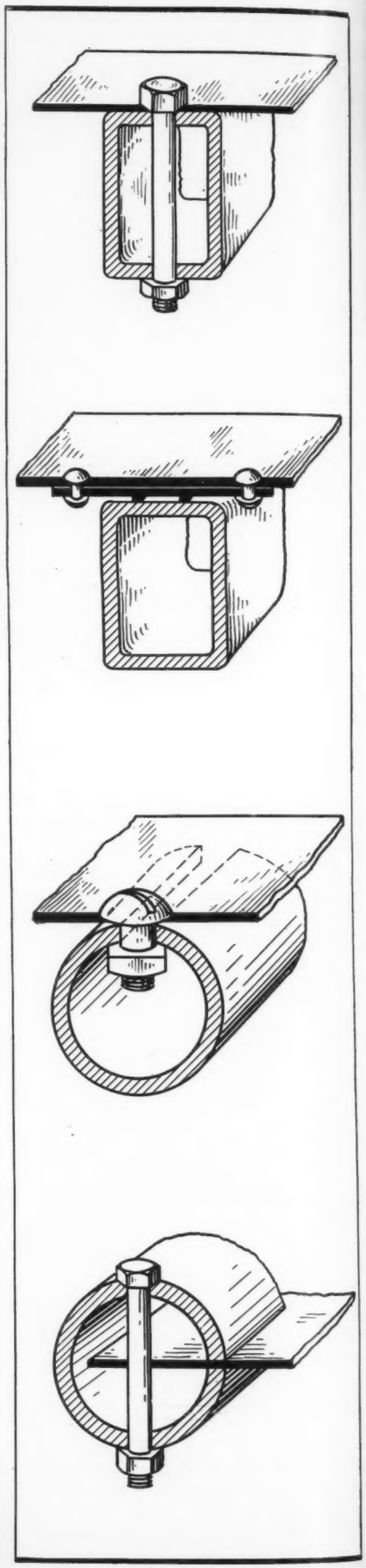
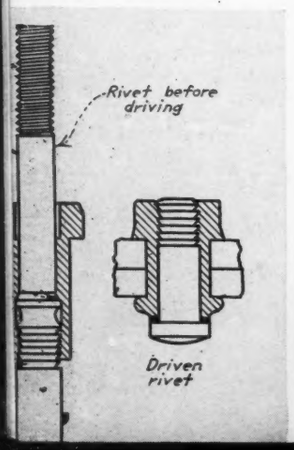
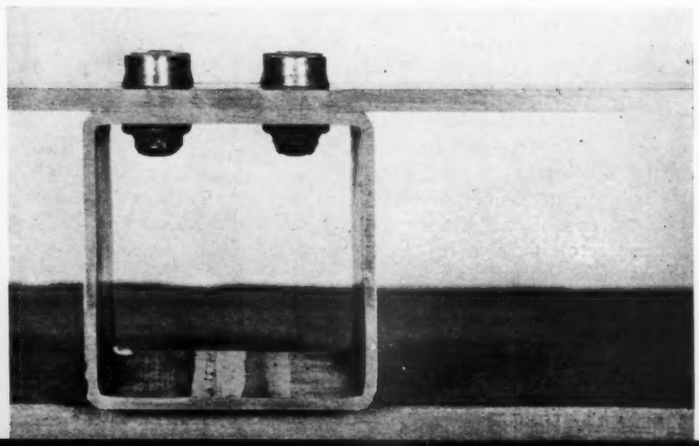


Fig. 5—Huck rivet before and after driving, and section of tube and sheet fastened with Huck rivets





LEFT: Arc welding is recommended especially for stainless sheets 20 gage and heavier. Jigs with chill plates are helpful to prevent buckling. RIGHT: Resistance seam welding, as in the General Electric refrigerator part, has the same general characteristics as spot welding and permits close automatic control of time, temperature and pressure

WELDED STAINLESS

Factors to Be Observed

A. E. TAYLOR
Chief Welding Engineer, The American Rolling Mill Company

Production considerations that will determine the type of stainless to be selected, the kind of welding process to be specified and the character of the structural design in order that the most efficient and economical processes may be employed

IN GENERAL, there are three kinds of stainless steels; the straight chromium grades that are hardenable by heat-treatment, the straight chromium steels that are non-hardenable; and the chromium-nickel grades. The first and third types fuse readily and by the application of suitable heat-treatment after welding, they may be returned to their original condition.

The non-hardenable straight chromium grades are subject to rapid grain growth at the welding temperature. This condition which can be relieved by subsequent heat-treatment, can be interpreted in terms of brittleness and loss of ductility.

Because of their characteristics, the non-hardenable straight chromium grades, which contain about 15 per cent or more of chromium, are not recommended for use in the "as welded" condition when they are subject to shocks or deformations at atmospheric temperatures. However, they are somewhat tougher and possess greater shock resistance in the "as welded" condition at temperatures of 200 deg. F. or higher.

In welding stainless containing about 13 per cent chromium air-hardening may result because of the temperatures involved. This condition, too, can be overcome by heat-treatment subsequent to welding. Also, by using a chrome-nickel grade welding rod, such as 24-12, the condition can be minimized.

The chromium-nickel grades are quite tough and ductile in the welded state. There is no need for subsequent annealing when the welded structure is used under conditions of normal atmospheric exposure or mild corrosive service. For more severe service, it is advisable either to specify an anneal after welding or to use low carbon stainless or the so-called "stabilized" grades, the use of which eliminates the need for annealing.

When the welded area is annealed it will possess the same degree of corrosion resistance as the metal itself. If chromium-nickel grades of stainless steel, containing appreciable amounts of carbon, are heated to the temperature range of 900 to 1,500 deg. F., the dissolved carbon begins to precipitate at the grain boundaries as chromium carbide. This leaves the material adjacent to these boundaries with a chromium content less than the minimum required for corrosion resistance.

These chromium carbides may be placed back in solution by heating to above 1,900 deg. F., followed by rapid cooling through the 1,500 to 900 deg. F. critical range. As the percentage of carbon present in the alloy decreases, there is markedly less tendency for carbide precipitation and in low carbon 18-8 and 19-9 stainless, this change of structure is practically negligible in its effect in most service environments.

Although carbide precipitation has a marked effect on corrosion resistance in severe service, it does not appreciably affect the physical properties of the alloy. When annealing after welding is not feasible, or when the corrosive conditions are severe, the low carbon or stabilized grades are recommended, depending on the severity of the service.

Electric arc welding will generally prove more satisfactory than gas for

Gas welding is recommended for sheets 20 gage and lighter. The sheet should be clamped and a slightly reducing flame used to avoid burning the weld

welding sheets of 20 gage and heavier. Gas welding is slower and is liable to cause more buckling or warping. On the other hand, although much progress has been made in the development of electric welding equipment for the lighter gages, gas welding is usually employed for stainless steel lighter than 20 gage.

It is advisable to use a jig wherever possible when welding stainless steel with the oxy-acetylene process, the jig serving to hold the edges parallel and keep warpage at a minimum. A gap equal to about one-half the thickness of the sheet should be allowed when the sheets are jigged so that good fusing and penetration of the filler rod can take place. As an aid in the elimination of buckling, copper chill plates clamped adjacent to the welding area help to absorb heat.

When designing a welded structure the coefficient of expansion of the metal should be considered. Straight chromium stainless steel has a coefficient of expansion about 10 per cent less than mild steel, whereas the chromium-nickel grades have an expansion coefficient approximately 50 per cent greater.

Although a neutral flame would prove most satisfactory, it is practically impossible to maintain. Therefore a very slightly reducing flame is advisable. An oxidizing flame is likely to cause burning of the weld. A flame too reducing in nature is conducive to carbon pick-up from the gas which will lead to a weak and brittle weld caused by carburization.

Flux coated rods contaminate and make the welds porous and weak, and should not be used for oxy-acetylene welding. Because the flame protects the side of the sheet on which welding is taking place, a flux is not needed. However, the flame will not protect the underside of a sheet, therefore, that side should be coated with a flux. If a flux with a heavy consistency is used the welding heat will cause it to fuse and protect the under surface.

Welding rods should be of a diameter approximately the same as the thickness of the sheet, but should have a higher alloy content to make certain the deposited metal will be of analysis similar to that of the base metal. There is some loss of alloy in the rod because of oxidation.

Chills to Remove Heat

For joining two pieces of stainless, arc welding is particularly recommended for 20 gage and heavier materials. In welding the chromium-nickel grades, the relatively large coefficient of expansion should be noted, and when these grades are used allowance should be made for expansion in the design of the structures to be welded. As in oxy-acetylene welding, it will be helpful to use a jig with a grooved chill plate and additional chill bars clamped adjacent to the weld to draw away heat and prevent buckling. The polished side of the sheet should be placed on the bottom to prevent damage to the surface.

In arc welding a flux-coated electrode should be used. The electrode should have an alloy content greater than that of the sheets to be welded, so that the deposited and base metal will be of similar analysis after welding. The flux as it fills in the weld protects the metal and prevents oxidation. The flux is also necessary to prevent porous weak welds, since there is no reducing flame to protect the weld.

Flux also acts as a stabilizing agent which helps to maintain a steady arc with an even flow of metal into the welded area. Slag formed by this flux coating will flow to the surface; this should be brushed off for the sake of appearance or before subsequent beads are laid on the weld. The welding electrode should be as low in carbon as possible, to prevent carburization of the weld and a resultant tendency to become brittle and weak. The electrode should be approximately the same or of a slightly greater thickness than the sheet to be joined.

Reversed polarity should be used when welding stainless steel sheets and light plates, that is, the work should be negative and the electrode positive. To minimize the danger of weld contamination the materials to be welded should be free from scale, grease and dirt.

In the electric welding of all chromium grades, a good fusion can be obtained if the welding current used for a given diameter of electrode is about 10 per cent less than that used for ordinary mild steel. This is necessary because of the low thermal conductivity, high electrical resistance, and the lower melting point of straight chromium steels. In welding straight chromium grades containing less than 15 per cent chromium, it should be kept in mind that the welds will respond readily to heat treatment and that air hardening, which takes place during the cooling from welding temperature, may be alleviated by annealing.

A fourth method of fusing stainless is flash welding, which in practice differs from welding mild steel only in degree of heat, time and pressure. In this type of welding it is necessary that the edges be parallel when placed in the grips to insure uniformity in heating or flashing. The pressure and timing are determined by the mechanical and electrical resistance offered by the metal. Pressure and timing also vary with heat developed and area to be joined.

Grips should be placed approximately one-half inch or less apart, depending on the thickness of the sheet. The distance between the inside faces of the grips should not be more than one-sixteenth inch when the weld is complete. Care will help eliminate waviness in weld.

When flash welding stainless, it is very important that a close adjustment of all the variables be maintained. If the metal becomes too hot, or if the time is too long before the upset, holes will be left in the finished weld because the metal will be fluid enough to flow away from the welded area. However, when automatic controls are used, and the ordinary amount of care is exercised, this type of welding will produce a uniform and solid weld.

Spot welding is another method that may be employed with excellent results if the operator exercises proper care in

adjusting the variables of current, time of current flow, pressure, and the diameter of electrode contact points. It is highly important to success in spot welding that the surfaces be free from scale, grease and dirt.

Equipment suitable for spot welding mild steel is equally suitable for use in welding stainless steel, but less heat and time are required for the stainless. If the current used in welding chromium-nickel grades is sufficient to thoroughly fuse the metal between the electrodes in the shortest possible time, the weld will be strong and the metal adjacent to the weld will not be impaired. If too much heat is generated or the timing of the application is too long, the metal surrounding the weld may be subject to failure by fatigue or have appreciably less corrosion resistance because of carbide precipitation. The electrode pressure should be controlled by compression of helical springs that have regulated stops or by air controlled pressure cylinders on the electrodes.

A sixth method of welding stainless steel is seam welding, which method has the same general characteristics as spot welding. The chief point of difference is that in place of using two electrodes, copper rollers are substituted and the pieces to be joined are passed between them. Adjustment for this kind of stainless welding is much closer for the chromium-nickel grades than for mild steel, whereas it is practically the same as mild steel for the straight chromium types.

Projection welding of stainless is a variation of the usual spot welding practice. In this type of welding raised spots are pressed into the sheets or plates to be joined. Then the parts to be fused are placed together between electrodes and pressure is applied, causing a weld between the raised portions. (See J. M. Cooper article, page 334, *P. E.*, Sept., 1937.)

Welded articles made from polished material very seldom are given any treatment other than grinding and polishing of the welded surface. Polishing increases the corrosion resistance of the metal. A procedure is suggested in Table I for grinding and polishing welds in stainless steel.

When welded products do not require a polished finish, the welding scale is removed by grinding, sand blasting or pickling. Scale and slag, which act as starting points for corrosion, should be removed completely.

A satisfactory pickling solution consists of a 10 per cent concentration by weight of 60 deg. Baume sulfuric acid mixed with about 10 per cent by weight of rock salt. This solution should be used at a temperature of about 150 deg. F. Following this operation the acid should be rinsed off in hot water and the work then immersed for about 30 min. in a warm (120–145 deg. F.) 10 to 20 per cent solution of 38 deg. Baume commercial nitric acid and then followed by a hot water wash.

Another pickling solution which can be used is a bath of 50 per cent muriatic acid at 120–150 deg. F. After a water rinse the work should be placed in a solution of 30 per cent nitric acid at 120–145 deg. F. for 20 to 30 min. and followed by washing with hot water.

Soldering Possibilities

Where welding is impossible or impractical, soldering is an excellent method of joining stainless steels. The first consideration in soft soldering or silver-soldering of stainless steel is their low heat conductivity. In general, the higher the percentage of the alloying elements (chromium and nickel) present in the stainless steels, the longer it will be necessary to apply heat. A higher temperature is not required, but the heat must be applied for a longer period.

Temperatures that are higher than necessary should be avoided because the expansion of the chromium-nickel stainless steels is greater than that of ordinary steels, and warpage of the finished product might result. To supply the additional amount of heating necessary for the soldering of stainless steel, a large sized soldering iron should be used or longer heating permitted.

Because of the resistant chromium oxide film present on the surface of all stainless steels, a stronger fluxing material than is required for ordinary ferrous metals is necessary to dissolve the oxide and etch the surface. There are many excellent commercial soldering fluxes available. Even a solution of uncut muriatic acid may be used with good results.

For sheets with a pickled finish, the only requirement is to have a clean surface before applying the flux. Polished sheets should be etched or roughened. A good roughened surface may be obtained by using a file or grinding wheel, or by the use of a solution of 63 per cent hydrochloric acid with 35 per cent ferric chloride and 2 per cent nitric acid. After the solution has etched the surface for about seven minutes the sheet should be wiped dry.

In soldering a piece of stainless, it is recommended that a small brush be used to apply the flux to prevent the flux spreading beyond the surface to be soldered. The solder should be applied in the usual manner. The operator should observe caution to avoid over-heating.

Inasmuch as stainless steels have a very high tensile strength compared with solders, it may be desirable on certain types of work to use a lock joint or tack welds to secure mechanical strength, with the solder acting only as a seal.

After soldering, the joint should be washed well with soap and water in which 5 to 10 per cent of washing soda has been dissolved, and then be rinsed with water and dried with a clean cloth. If the excess flux is left on the weld it will turn the metal dull and cause rust at the joint.

For silver-soldering, the temperature employed should be kept below those (1,500 deg. F. and higher) at which grain growth, which causes embrittlement, occurs in the straight chromium grades. The lower melting temperature of silver-solders, compared with welding, lessons the tendency toward warping or scale formation. Silver-soldering produces a fairly high strength joint that has a good color. It is essential that all the excess flux be removed after the soldering to prevent further action of the fluxing mixture on the stainless steel, for the same reason mentioned above.

TABLE I—SUGGESTED PROCEDURE FOR GRINDING AND POLISHING WELDS IN STAINLESS STEEL

Operation	Abrasive	Grit No.	Type of Wheel	Surface Speed Ft. Per Min.	Wheel Diam.	Rev. Per Min.	Grease	Finish
Rough-Grinding	Aluminum Oxide	24-30	Rubber	6,500-9,500	5"	4,975-7,250	No	
	Aluminum Oxide	24-30	Rubber	6,500-9,500	5"	4,975-7,250	No	
	Silicon Carbide	30	Rubber	6,500-9,500	5"	4,975-7,250	No	
Finish-Grinding	Aluminum Oxide	36-50	Rubber	9,000-9,500	5"	6,875-7,250	No	
	Silicon Carbide	36-50	Rubber	9,000-9,500	5"	6,875-7,250	No	
Polishing	Aluminum Oxide	80-100	Muslin	6,000-8,000	5"	4,580-6,100	No	
	Aluminum Oxide	120	Soft Muslin	6,000-8,000	5"	4,580-6,100	Yes	No. 4
	Pumice & Lime	Pumice & lime in oil and kerosene	Tampico Brush	6,000-7,000	12"	1,900-2,250	Yes	No. 6
	Black Emery or Aluminum Oxide	180*	Soft Muslin	6,000-8,000	5"	4,580-6,100	Yes	No. 7
	Black Emery or Aluminum Oxide	220-380*	Soft Muslin	6,000-8,000	5"	4,580-6,100	Yes	No. 8
Buffing Cutting Down	Stainless Buffing Compound		Unbleached Muslin	5,000-5,700	8"	2,400-2,700		
Color Buffing	Stainless Buffing Compound		Unbleached Muslin	5,000-5,700	8"	2,400-2,700		

*Plus Buffing

AUTOMOTIVE DIFFERENTIAL

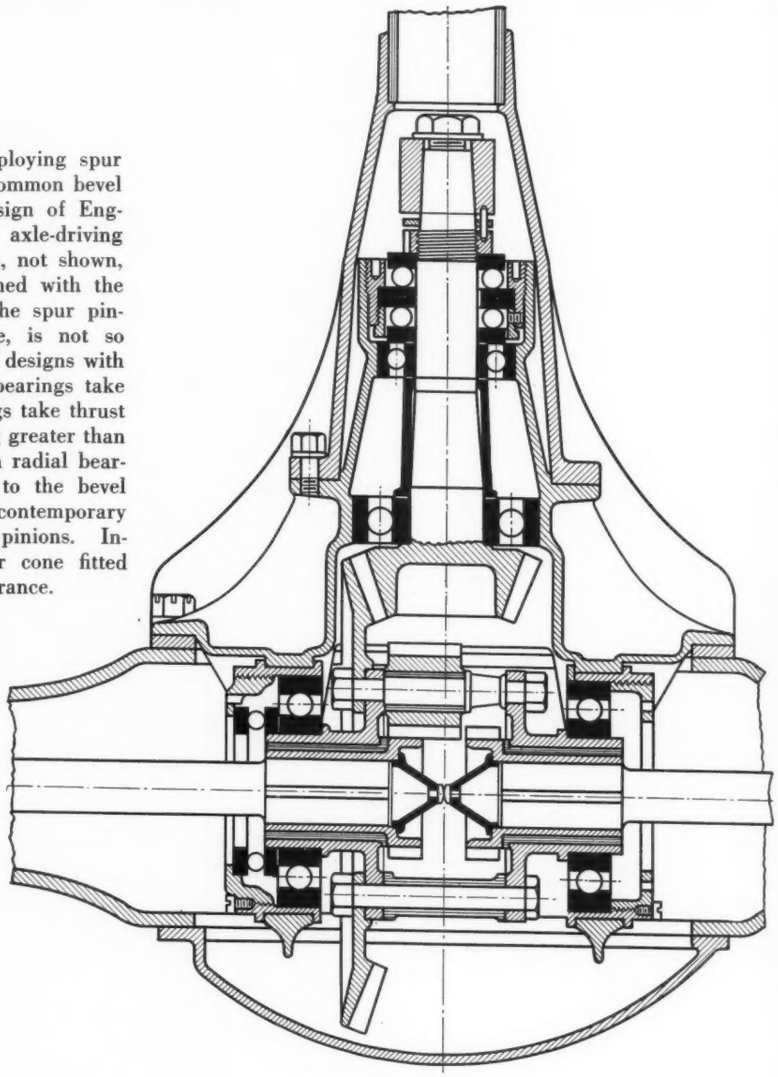


Fig. 5—This interesting drive, employing spur differential pinions instead of the common bevel pinions, was used on an early design of English passenger car. Right-hand axle-driving gear is meshed with a spur pinion, not shown, which is similar to and also meshed with the differential spur pinion shown. The spur pinion design, though less expensive, is not so compact and light in weight as are designs with bevel pinions. Conventional ball bearings take radial loads and ball thrust bearings take thrust loads, the number of bearings being greater than in later types. Heaviest load is on radial bearings placed as close as possible to the bevel pinion, which is overhung. Other contemporary designs employ straddle-mounted pinions. Interesting also is the spun copper cone fitted over the housing to improve appearance.

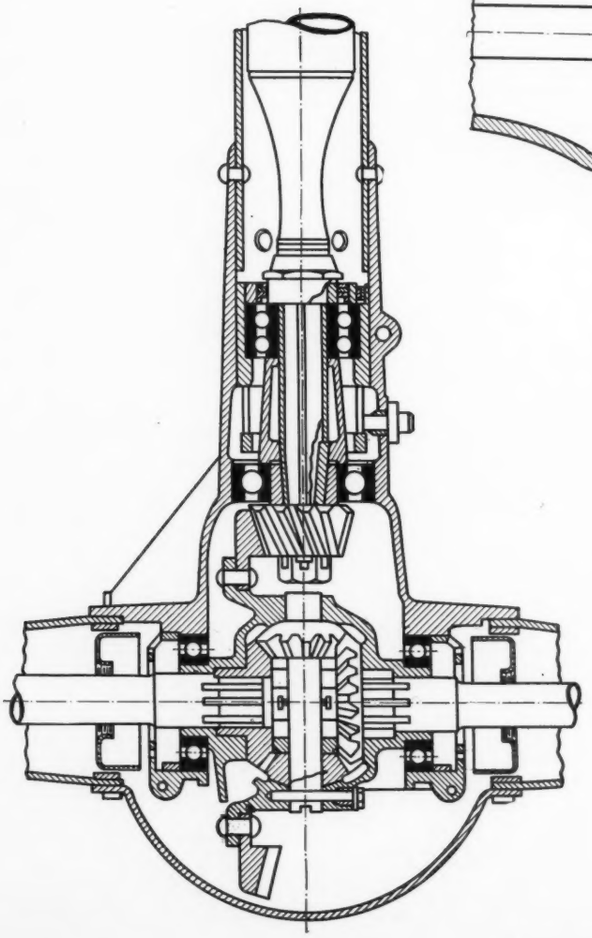


Fig. 6—Rear axle assembly, of recent, conventional type, with spiral-bevel final drive. Mounting is entirely on ball bearings. Bevel pinion is overhung, but use of torque tube facilitates provision of wide spacing of bearings. Single-row ball bearing is located as close to pinion as possible and double-row bearing is at far or forward end of pinion shaft. Ring gear is riveted to differential carrier, which rotates in radial ball bearings with sufficient thrust capacity to take ring-gear thrust. Also provided are means for accurate adjustment of the spiral bevel gears and grease retainers for holding lubricant within housing.

GEAR MECHANISMS—II

Further examples of rear axle designs that have been used on passenger cars and trucks for transmitting and distributing torque equally to both driving wheels

HERBERT CHASE

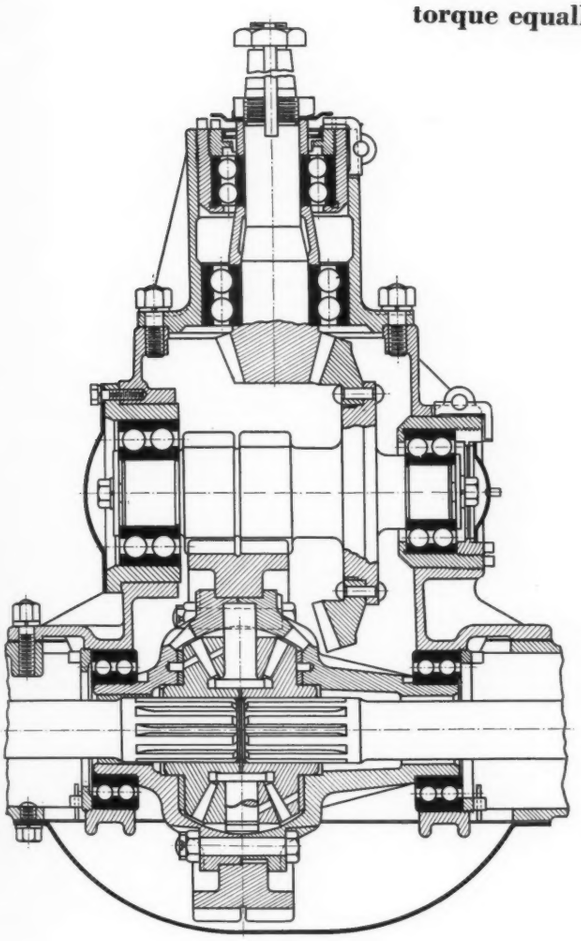


Fig. 7—Double-reduction rear axle in which first reduction is by bevel gears and second by pair of herringbone gears of the spur type, all shaft axles being in the same plane. Used where greater reduction than is feasible with a single step of bevel gearing is required, as for heavy trucks. Straight-tooth, spiral or hypoid bevel gears can be employed in similar designs, and straight, helical or herringbone spur gears can likewise be used. In double-reduction drive shown, all gears are supported in cast carrier bolted to housing. Double-row ball bearings are provided, the forward bearing on the bevel pinion shaft taking thrust as well as radial load.

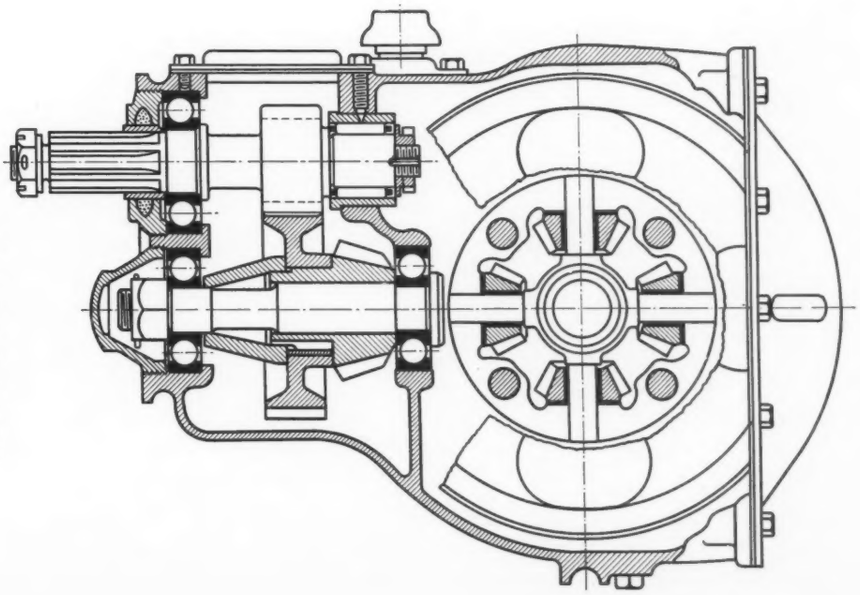


Fig. 8—Another double-reduction truck drive, in which, however, the first reduction is by spur gears and the second by bevel gears. All gears, including the bevel pinion, are straddle-mounted, the latter being located very close to the bearing seated directly in the housing. With this design, the heavier load is imposed on the bevel gears, whereas with the design shown in Fig. 9 the reverse is true.

Question and Comment

Keeping an Index-Less File For Magazine Clippings

A. W. EIDMAN
Cleveland Heights, Ohio

Every engineering department at one time or another makes a valiant attempt to garner the more important information from the monthly avalanche of engineering magazines and file it. The scrap-book and the complete systems with cross-references invariably become so unwieldy that the project quickly dies of its inherent complexity. Any data system to be workable must be childishly simple, easily understood, and require a minimum of time to operate it.

One obviously simple method, which really works, consists of filing all clippings in 8½ x 11 in. manila folders, each index tab of which indicates the nature of the contents. The folders are filed alphabetically according to subject in a vertical file. A typical run of titles in a product-development department might read as follows:

Plastics, Thermo-setting
Plastic Working of Metals
Plywood
Pre-finished Strip Steel
Processes
Products, Competitors'
Resins

These folders, well indexed, form the idea and information file on products, processes, machines and competitors' activities.

To operate this system to its best advantage, arrange to have all magazines so routed as to end in the product-development department. Once a month, they can be rapidly skimmed and all pages of any possible future interest clipped. Then, all related pages should be fastened together with a desk stapler. When more than one article of interest comes on the same page, a memorandum should be made out referring to the other article and should be inserted in the second folder in which the clipping would normally have been filed. Finally, without ceremony, drop the clippings in the proper folders and forget the matter. There is no index.

When any folder becomes too bulky, its contents should be reclassified. Do not attempt to add a file index or cross-references; the simplicity of the method is its virtue.

Three Methods of Mounting Reciprocating Drive Units

W. T. SHALER, ENGINEER
Ajax Flexible Coupling Company

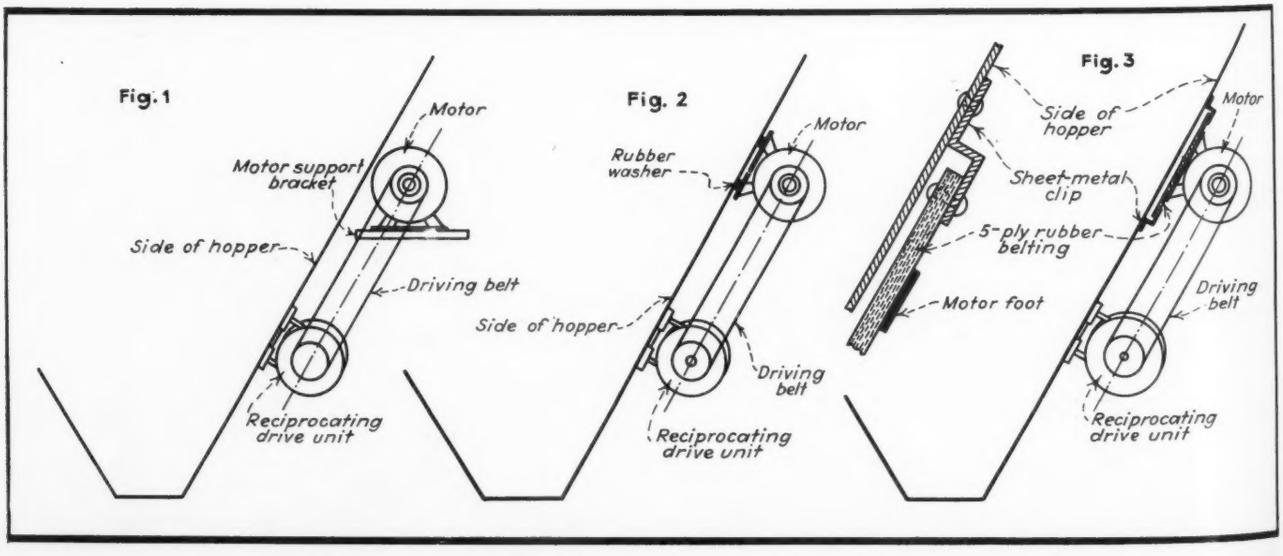
With the increasing use of reciprocating drive units for preventing both sticking and bridging in hoppers, the problem of mounting them properly is being more frequently encountered by engineers responsible for the design of plant machinery. For this reason, three simple mountings will be discussed in the following paragraphs.

A reciprocating drive unit is a mechanical vibrator or oscillator. It must be driven by some outside source of power, a small electric motor usually being most convenient. However, since vibration is detrimental to motors, it is best not to mount the motor rigidly on the bin or hopper being vibrated.

The preferred method of mounting the motor is shown in Fig. 1. Mounted on a separate support in this way, the motor may be located on either side of the drive in almost any position so long as the pulley centers are approximately parallel to the side of the bin. It is best, however, to keep the belt as short as practical, and a V-belt is preferable to a flat belt.

Sometimes there is no convenient place to mount the driving motor on its own support. In such instances the motor can be mounted directly on the side of the bin, provided it is shielded effectively from the vibration which will be set up. One method of doing this by means of rubber washers is illustrated in Fig. 2. The rubber washers should be fairly soft and thick. It is also important that the motor be mounted as far as practical from the drive unit and at the point of least vibration.

Another method of insulating a motor



from vibration when it is necessary to mount it directly on the hopper is illustrated in Fig. 3. This mounting, although it is a little more expensive than that shown in Fig. 2, will absorb more vibration. Two Z-bars are riveted to the side of the bin, a strap of 5-ply rubber belting is riveted between the Z-bars, and the motor is mounted on the belting. Though relatively simple, the method is very effective.

In general, a hopper or bin should be vibrated just enough to produce maximum results. On large structures, it is generally better to use two or more small drive units instead of one large unit.

Oil-Heater Finish

To the Editor:

In the Product Developments department of your September issue, the Spencer Heater Company's 1937 model domestic oil heater was shown as an interesting example of appearance-styling from the standpoint of shape or form. Not mentioned in your story, but of equal interest to many of your readers, is the fact that this heater also exemplifies certain modern tendencies in appearance-styling from the standpoint of product finishing.

Before selecting the finish to be used, Mr. Gilbert Rohde, who designed the Spencer heater, studied the question of color carefully. Previous models of Spencer heaters had been finished in bright reds and greens. These appealed strongly to buyers at first, but Mr. Rohde found that women are now asking for colors that give them more leeway in decorating basement rooms. He therefore decided that the colors to be used must be less striking but no less attractive to women.

He also decided that the colors to be used must prove satisfactory under two very different sets of conditions: (1) in the brightly illuminated showroom and (2) in the dimly lighted basement. Because many colors that are attractive in bright lights lose their character in shadows or dim lights, the range of choice was still further narrowed.

The problem was finally solved by using a lustrous lacquer-enamel, Metalustre, in two shades of bluish-gray for the large areas of the heater with certain details in strong red and in polished aluminum. This combination produced the desired visual appeal.

Not only is this finish attractive, but it also effectively protects the metal of the heater from corrosion. The protective characteristics are provided by the use of a baked synthetic primer under the finishing coat of Metalustre. This type of primer aids in securing a good finish because it dries "out of dust" in five minutes, adheres strongly to the metal, and not only is very durable but also is resistant to heat and moisture. The finish of the heater is pleasing to the eye and will maintain its good looks for a long time after the heater is placed in service. —Gustave Klinkenstein

Vice-President and Technical Director
Maas & Waldstein Company

Further Solutions to Angular Velocity Problem

To the Editor:

The following is suggested as a simple solution to Mr. D'Entremont's problem published in your August issue. It is well known that if the plane of the circle shown in the sketch presented with the problem is rotated about the long diameter of the ellipse until the plane of the circle makes with the plane of the ellipse (the plane of the paper) the angle γ whose cosine is b/a (where a and b are the semi-major and semi-minor diameters of the ellipse), the ellipse will be the orthographic projection of the circle, and b/a will equal PC/AC, where C is the point at which AP (produced) cuts the long diameter of the ellipse.

Then from triangles OAC and OPC:

$$\tan \alpha = AC/OC$$
$$\tan \beta = PC/OC$$

Dividing one by the other we obtain

$$\frac{\tan \alpha}{\tan \beta} = \frac{AC}{OC} \times \frac{OC}{PC} = \frac{AC}{PC}$$

$$= \frac{1}{\cos \gamma} \qquad (1)$$

In this expression α and β are variables and γ is a constant.

Then, by differentiating Equation (1) with respect to either of the variables, we obtain after a few simple and obvious trigonometric transformations:

$$\frac{\mathrm{d}\,\beta}{\mathrm{d}\,\alpha} = \frac{\cos \gamma}{1 - \sin^2 \gamma \sin^2 \alpha} \qquad (2)$$

This is the relation desired by Mr. D'Entremont. Perhaps it might be well to add, however, that Equations (4) and (5) are the well-known displacement and velocity relations for the 4-link spheric linkage called Hooke's joint—relations given in all elementary books on mechanism.

Putting the matter kinematically, if we imagine two shafts, *2* and *3*, to be connected to each other by a universal joint, the axis of the first being perpendicular to the plane of the paper at O, and the axis of the second perpendicular at O to the plane of the circle whose orthographic projection on the plane of the paper is the given ellipse, then Equation (1) gives the relation between the angle α turned through by shaft *2* in time t and the angle β turned through by shaft *3* in the same time.

Also the right-hand side of Equation (2) is the expression for the angular velocity ratio N_{31}/N_{21}, in which N_{21} is the angular velocity of shaft *2* relative to link *1* (the link, not shown in the figure, that holds the two shafts in a fixed relation to each other). Similarly, N_{31} is the angular velocity of shaft *3* relative to the same link.

There is a simple and elegant geometric construction for the angular velocity ratio N_{31}/N_{21}—or, what is the same thing, for the graphic differentiation of Equation (1)—in the late Prof. S. Dunkerley's book, "Mechanism," page 203, 1904 edition. —W. H. Rasche

Virginia Polytechnic Institute

To the Editor:

If it is not too late, I would like to supplement the comment published in your September issue on my solution to Mr. D'Entremont's problem.

An ellipse may be traced by a point located on a pinion between its center and inside its pitch diameter, the pinion rolling inside an internal gear twice the diameter of the former.

From this construction a formula can be derived for the calculation of the angular velocity of OB with respect to OA. The derivation of the formula is rather complex, and only the following final result will be stated:

$$\frac{\mathrm{d}\,\beta}{\mathrm{d}\,t} = \frac{k^2 + 1}{k^2 + 1 + 2k \cos 2\alpha} \times \frac{\mathrm{d}\,\alpha}{\mathrm{d}\,t}$$

Where $\dfrac{k+1}{k-1} = \dfrac{\text{major axis}}{\text{minor axis}}$

and $\dfrac{\mathrm{d}\,\alpha}{\mathrm{d}\,t}$ = angular velocity of OA.

This equation will be found to be less laborious than the one previously submitted for this relation because it involves fewer and simpler calculations.

—Frederick W. Seybold

Westfield, N. J.

To the Editor:

After solving the problem on angular velocity, I cannot help wondering whether it involves a real engineering application or is just something on which to use up pencil and paper and to keep one's mind occupied.

It seems highly improbable that, after stating the problem so aptly, Mr. D'Entremont could not solve it himself. It was an interesting problem, but what for? —F. M. Tousley

Detroit, Mich.

To the Editor:

Unfortunately I cannot disclose for publication the exact application of the angular-velocity problem. However, it was not originated as a problem in calculus but occurred in the solution of an engineering problem. The machine, in the design of which this problem was encountered, is still in the process of development and must be kept confidential.

When the problem arose, I found that my calculus had become rusty from infrequent use during the last few years and I therefore had to go back to my books and scratch my head a few times before I could solve it to obtain velocities, accelerations, orbits and other values desired. Although there were a number of other aspects to the problem, the one submitted was the most difficult for me to solve. Besides being curious to see how other readers would attack the problem, I submitted it because I thought it might be of general interest, and this has proved to be true.

The problem is the case of a particle acted on by two simple harmonic motions of different amplitude and 90 deg. difference in phase, causing elliptical harmonic motion.

My own solution was carried a small step father than was asked for in submitting the problem, thus:

$$\frac{d\beta}{d\alpha} = \frac{Rr}{R^2\cos^2\alpha + r^2\sin^2\alpha}$$

$$= \frac{Rr}{x^2 + y^2} = \frac{Rr}{\rho^2}$$

Where ρ is the radius vector *OP*.

Also, $$\frac{d\beta}{dt} = w_\beta = \frac{d\beta}{d\alpha} \times \frac{d\alpha}{dt}$$

$$= \frac{Rr}{\rho^2} \times w_\alpha$$

My thanks to *Product Engineering* for the publication of the problem and for the solutions submitted by the readers. Should another such problem present itself, I will also submit it to the Questions and Comment department, if you wish.

—H. W. D'ENTREMONT
East Orange, N. J.

[*Editor's Note:* That Mr. D'Entremont's problem proved to be of general interest is evidenced by the solutions and comments from readers published in this and in the September issue. Similar solutions were also received from the following readers, and are hereby acknowledged:

E. R. Coe, Dayton, Ohio; Count Harvey, Denver, Colo.; G. M. Mast, Chicago, Ill.; C. Neklutin, St. Louis, Mo.; Edwin Rayburn, Mt. Vernon, N. Y.; Hans Schemm, Upper Darby, Pa.; and Norman M. Wickstrand, Bristol, Conn.

Mr. D'Entremont and other readers are invited to submit similar problems, which they believe may be of general interest, to the Questions and Comments Editor for possible publication in this department. Those in which the engineering application can be divulged will be given preference.]

Magnaflux Filter

To the Editor:

With respect to the inquiry of C. H. B. on page 315 of your August issue, we are pleased to inform him and other readers who may be interested that since Magnaflux powder is highly magnetic we feel sure that it can be separated from coal oil by our Ferrofilter.

The Ferrofilter consists of magnetized screens contained within a cylindrical coil. The screens, shaped like pancakes and piled one above the other, are removably placed inside a cylindrical casing surrounded by the coil and by the housing of the device. Electric current in the coil windings magnetizes the screen edges. The material is fed into a bowl located above the screens, and passes down through them. The iron particles accumulate on the upper and lower edges of the screens.

A float valve regulates the discharge so that the screens are always flooded, assuring a uniform, slow flow of the material through the whole cross-section of the screen space. An automatic magnetic valve drops down if for any reason the power supply to the machine is cut off, preventing contamination of the cleaned product.—SAMUEL G. FRANTZ.
S. G. Frantz Company,
New York, N. Y.

To the Editor:

For the benefit of C. H. B. and other readers who may have a similar problem, I wish to advise that the Stearns Magnetic Mfg. Co., of Milwaukee, Wis., has developed a separator which effectively performs the required functions.

This magnetic separator is designated as the Stearns Type QS and utilizes the wet magnetic filter method of extracting fine iron particles from oils, ceramic slip, frit, glazes and other similar materials of about the same specific gravity.

The principle of operation involves a cartridge containing a highly magnetized, inductively energized screening element so designed as to present a large number of lineal feet of active magnetic collecting edge.

The material to be separated is poured into a bowl from which it is fed into the screening unit. The latter is activated by a tapered magnet of low-carbon dynamo steel having a machined cavity which completely surrounds and incloses the coil windings. The windings are protected by a sealing compound against the possible entrance of any moisture which might affect the operating efficiency of the unit. The screening element is readily removable for cleaning. A direct-acting check valve automatically closes when the current is interrupted, thus avoiding contamination.

—H. W. HARMAN
Stearns Magnetic Mfg. Company,
Milwaukee, Wis.

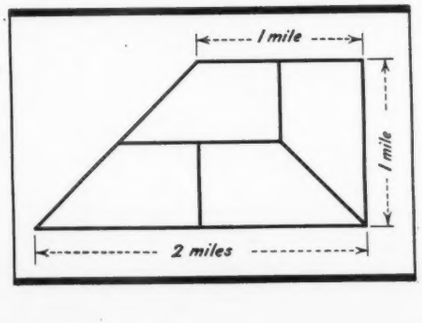
Can You Work This One?

H. E. SMITH

This Month's Problem—

Mixed Cargo

A barge, when laden to full capacity with coal, carries a load of 50 tons. When the coal is replaced with cork, the cargo weighs 15 tons. On one trip, however, it was fully loaded with a mixed cargo of coal and cork, the coal weighing five times as much as the cork. What was the total weight of the cargo on this trip?



Solution to Last Month's Problem—

Trig Teaser

Here is how the farmer divided his section and a half of land so that each of his four sons would inherit a parcel not only of the same area but also of the same shape as the other three. Actually, one of the parcels is not truly the same shape as the others, but is a mirror reflection.

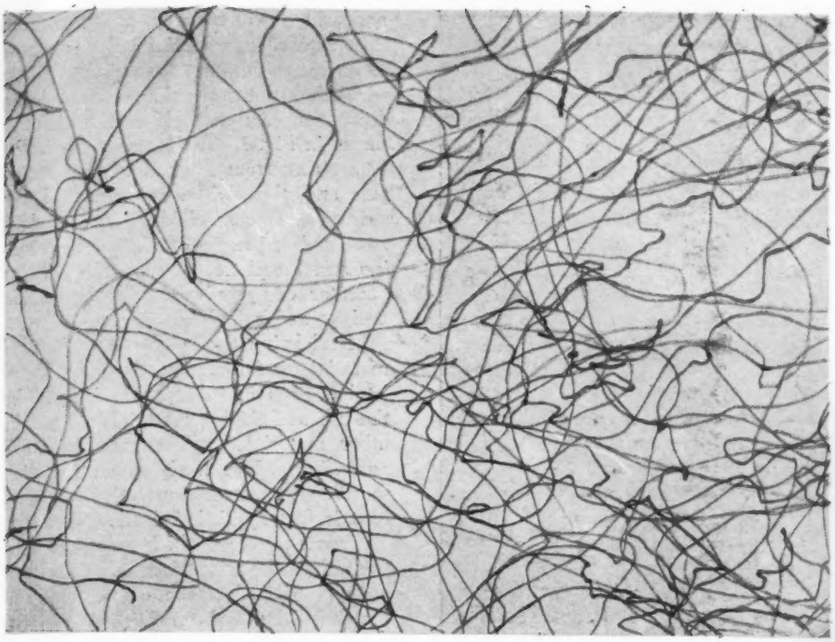


Fig. 1—(Above)—An example of "veiling," an effect produced by "strings" of lacquer ejected from a specially constructed gun. The lacquer used is compounded so that it will not flow when it hits the surface being decorated, which previously has been given a ground coat of the background color desired. The size and diameter of the "strings" can be controlled so as to produce heavier or lighter veiling while further variations can be obtained by changes in the design of the veiling pattern and the use of different color combinations

Fig. 2 (Below)—Two examples of imitation marble finish, the one using a white ground coat and the other a black ground coat for the background. The red and blue "marbleizing colors" were floated on the surface of water and the ground-coated panel carefully dipped into the water and gently withdrawn, the various colors of paint adhering to its surface. After drying, a top coat of lacquer is applied and is buffed to a high gloss finish

DECORATIVE EFFECTS

With Organic Finishes

M. H. CORBIN
Research Director, The Arco Company

By taking advantage of peculiar properties of materials, paint chemists have made available a great variety of color and decorative effects that do not require any special talent or equipment for their production. Some striking effects are illustrated here

ORIGINALLY organic coatings were used solely for decorative purposes, the design of the article being enhanced by the proper choice of finish and color combinations. Sales are stimulated by unusual color effects and often contribute greatly to attention compelling values. A great variety of unusual color effects can be produced by organic coatings such as the various types of paints, varnishes, enamels and lacquers.

Most of the unusual finishing effects were developed through taking advantage of mistakes in the formulation or application of the finish. For example, the discovery of the wrinkle finish came about as the result of an excessive amount of drier in an alkyd resin and also through using partially cooked Tung oil in a varnish.

Similarly, decorative finish effects obtained by unusual methods of applying unusual coating materials were discovered. An example of this is the type of finish in vogue some years ago, but

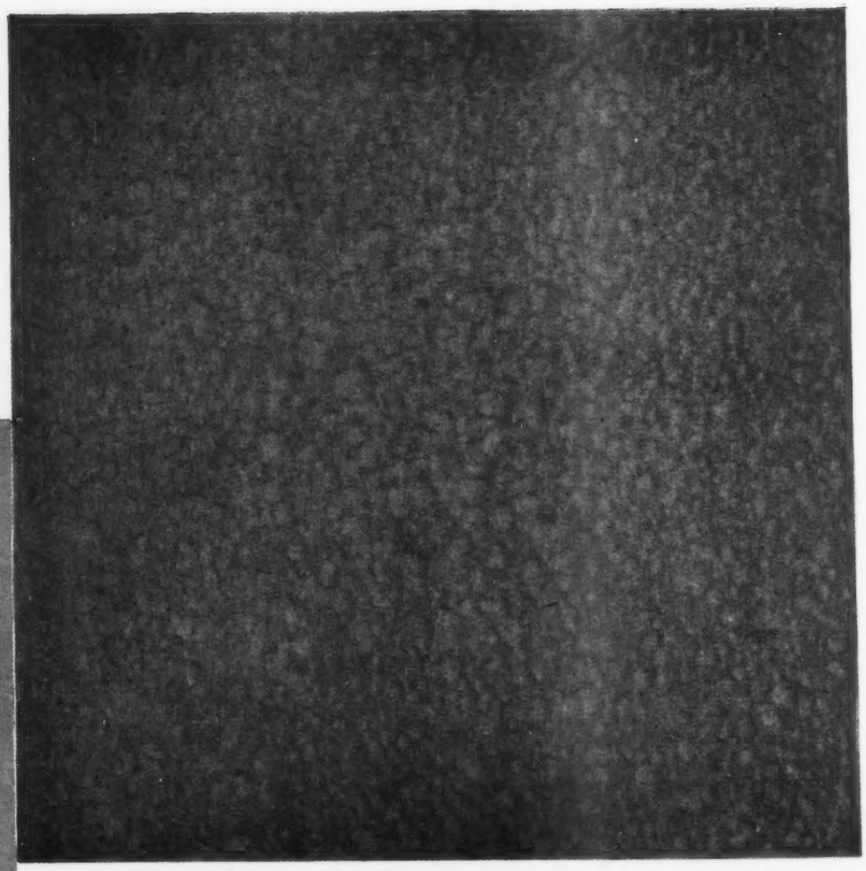


Fig. 3—A hammered silver or copper effect which is obtained by applying a coat of clear lacquer over a partially dried ground coat of either copper or silver bronze

Fig. 4—Wrinkle finishes may vary from very fine to coarse wrinkles. Here the red wrinkle in the border formed by the black stripe has been shaded with a darker red lacquer

not used as much today, known as veiling lacquer. The material is formulated so as not to flow but to stay put exactly where it hits the panel or surface being decorated. An example of this effect is shown in Fig. 1. The material is ejected as a string from a specially constructed gun and the size or diameter of the string can be controlled so as to produce more or less prominent veiling. By shading and the choice of proper colors the operator can produce many interesting designs and color effects.

Metal being the most commonly used material for fabrication, the paint chemist has been called upon to imitate, by the use of finishing materials on metals, other materials such as marble, wood and cloth. Fig. 2 shows an imitation marble effect. In this operation, a ground coat is first applied and allowed to dry. The various colors which are to be used to produce the marbleized effect are then floated on the surface of water. The panel which has been finished with the ground coat is then dipped gently into the water. As the panel is slowly withdrawn from the water the various colors of paint adhere to the surface of the

Fig. 5—A "blush" finish which changes color, depending on the angle from which it is viewed. It was made by spraying a deep wrinkle finish first from one side with green and then from the opposite edge with yellow

panel. It is then allowed to dry and a top coat of lacquer is applied and buffed to a high gloss surface. On one of the panels shown in Fig. 2 a white ground coat was used, on the other a black. On both panels the marbleizing colors are red and blue.

Imitation wood finishes also can be produced by roller graining from an etched plate over a ground coat, lithographing, or hand graining. Probably the most universally used method is roller graining from a copper plate etched with the desired grain effect. The plate is covered with graining ink and the surplus ink scraped off, leaving ink only in the depressions in the plate. A composition roller is rolled over the plate, picking up the ink and thereby transferring the pattern to the roller. The composition roller is then rolled over the surface to be finished, a ground coat having been applied to it previously. After the ink has dried thoroughly, generally by baking, a finish coat of lacquer or varnish is sprayed on. Either air dried or baked finishes can be used.

The most recent type of novelty finish is a hammered silver or copper effect such as shown in Fig. 3. This is obtained by spraying over a partially dried ground coat of copper or silver bronze, a coat of clear lacquer.

Wrinkle Finishes

Wrinkle finishes are applied in one coat which is baked for one hour at 250 deg. F. to 300 deg. F. They can be obtained in various colors and will take as second coats other types of paint for striping, shading, or other effects as desired. Wrinkling is primarily the result of uneven drying of the surface film which may be induced by partially cooked Tung oil in a varnish, an excess of drier in an alkyd resin or other combinations. A typical wrinkle finish is shown in Fig. 4 wherein a black stripe was applied over a red wrinkle finish and the outer border thus formed was shaded with a darker red lacquer. The size of the wrinkle can be varied from very fine to a coarse "pine tree" type.

Another wrinkle effect is shown in Fig. 5. After the panel had been covered with a coarse red wrinkle finish it was held horizontally about in the plane of the spray gun and a green lacquer was sprayed on it at a sharp angle and from one side only. Thus one side of the wrinkles was colored green. The operation was then repeated from the

Fig. 6—The two panels below are examples of crackle finish wherein a highly pigmented lacquer is applied over an air dried lacquer first coat

Fig. 8—Effects produced by putting an organic salt in the lacquer. As the solvent evaporates the solution becomes super-saturated and the salt crystallizes

Fig. 7—An imitation grain leather finish obtained by applying a black or brown coat of crackle lacquer as the final coat

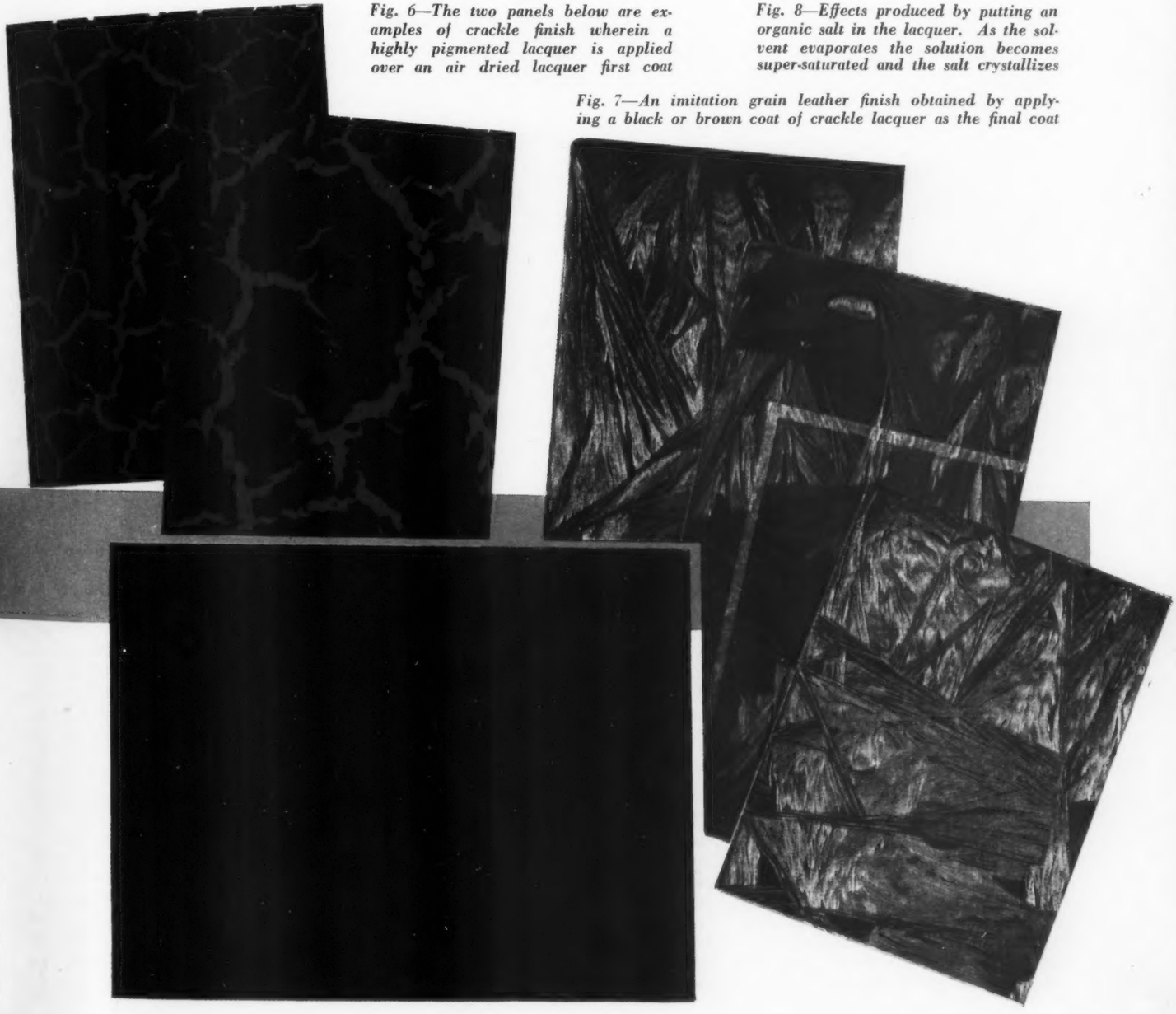


Fig. 9—Decorative effects produced by daubing or mottling with a rag

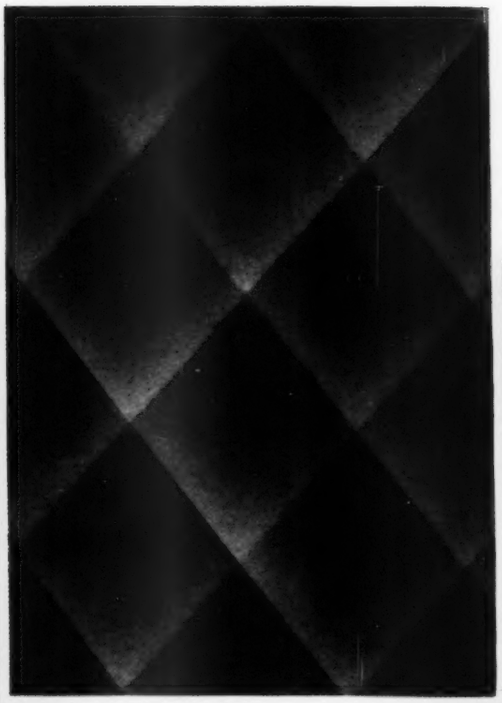


Fig. 10—An effect produced by stenciling, known as "paper shading." Instead of a straight edge, as used here, the paper may be cut in a design

Fig. 11—Effects produced by a heavy coat of knifing glaze over a coat of primer. The glaze is daubed with a sponge or rag and the finish coat is then applied

opposite side and a yellow lacquer was sprayed on. The final result was a variegated finish which changes color depending on the angle from which it is viewed.

Frosted Finishes

In foul ovens, wood oil tends to crystallize. The paint chemist has taken advantage of this to produce finishes that give a crystallizing or frosting effect. This finish also can be obtained in a variety of colors and sizes of crystals. It is applied in one coat and baked in a foul gas oven at a temperature of 250 deg. F. to 300 deg. F. for 45 min. to one hour.

In ordinary paint formulation it was also found that if too much pigment were incorporated into a vehicle, checks or cracks in the finish developed. The paint chemist has taken advantage of this phenomenon also, to produce crackle lacquer, an example of which is shown in Fig. 6. To produce this finish, a coat of highly pigmented lacquer is applied over a lacquer first coat which previously has been air dried. A heavy coat of this material produces large cracks, while a thinner coat produces fine cracks. It is advisable to apply a clear finishing lacquer over the crackled surface.

By using a ground coat of one color and a different colored crackle lacquer various effects can be produced. On the other hand, if a black or brown lacquer is applied as the final coat instead of a clear lacquer, an imitation grain leather finish as shown in Fig. 7 is obtained.

In the formulation of another novelty finish, the paint chemist takes advantage of the crystallization of organic salts. An organic salt is put into a lacquer, and as the solvent evaporates the solution becomes super-saturated, and crystallization takes place. Many varied artistic effects can be produced as seen in Fig. 8. If crystal lacquer of one color is put over a different colored ground coat, the crystalline structure is made more prominent. Also shading or antiquing the crystalline finish produces very pleasing effects.

Effects with Lacquers

Many decorative effects can also be produced by the finisher with his standard lacquer materials. Fig. 9 shows finishes produced by means of a rag. First a cream colored lacquer ground coat was applied and then a coat of green japan color was applied by means of a rag, daubing or mottling it on. This was followed by a coat of clear lacquer.

In Fig. 10 is shown an effect produced by stencils. A ground coat of black was applied and allowed to air dry. Then a straight edge or sheet of paper was laid diagonally on the panel and a mist coat of gold bronze was sprayed once across it. The paper or straight edge was then moved back about an inch and the operation repeated. The panel was then turned through a 90 deg. angle and the operation repeated.

In Fig. 11 is shown the effects which can be produced by means of a knifing glaze and a rag. The panel is first covered with a coat of primer, and then a heavy coat of knifing glaze is applied. Various intricate designs can be obtained on the coat of knifing glaze by daubing with a rag or sponge. A twisting motion may be used to produce a circular pattern. A finish coat is then applied. This is either a bronzing liquid containing aluminum or copper or a colored pigmented material. As a final step the high lights are shaded.

By no means all of the possible decorative effects obtainable with organic coatings have been mentioned in this article. For the preparation of the panels shown in this article the author is indebted to Mr. A. E. Wendorf who is in charge of the finishing laboratory of The Arco Company.

News

Aluminum Coated Steel Now Available

COMMERCIAL production of aluminum-coated steel, known as Alplate, by the Reynolds Metals Company at Knoxville, Tenn., has been announced. Patents have been allowed in all important countries.

Although ferrous metals are readily coated with zinc or tin, it has not been possible heretofore to coat such metals with aluminum by the ordinary process of immersion in a molten bath because molten aluminum is very readily oxidizable. The surface becomes coated with an oxide film of high surface tension which strongly resists penetration. The interposition of this film between the aluminum and the article to be coated results in failure to obtain a uniformly adherent coating by the ordinary dipping process.

The essence of the new Alplate process lies in subjecting the ferrous metal to the action of a reducing gas, such as hydrogen, before passing into the aluminum bath. This results not only in the removal of oxygen and reduction of oxides on the surface of the ferrous metal, but also serves to charge it with enough of the reducing gas to insure a complete union with aluminum at the time of immersion.

Apparently there is a critical temperature at which the behavior of the gas-charged ferrous metal toward molten aluminum is most favorable for the deposition of a tenacious and uniform coating. Thus for steel strip moving through a chamber of hydrogen on its way to the aluminum bath, the temperature is 732 deg. C., or 1,350 deg. F. The temperature may vary with different metals and reducing gases; but for any combination there is a temperature at or above which the gas-charged metal to be coated forms a satisfactory union with molten aluminum without oxidation at the interface of the two metals. Heating may be accomplished through the medium of the hot reducing gas or by means of a current of electricity.

The process is applicable to the production of aluminum-coated wire, rod, sheet, and other forms in a continuous manner. The coating and bond are substantially uniform in thickness, and so tenacious that the products can be subjected to metal working processes without cracking or detachment of the coating.

It is reported that aluminum-coated steel can be heated to 1,000 deg. C. for 1,000 hours without destruction; also that, in wire form, it can be used for resistor heaters. Compared with solid aluminum the coated steel shows a high resistance to fatigue. A minor characteristic is that aluminum-coated steel can be dyed like solid aluminum. The new product resists abrasion, corrosion, and acids better than does tin- or zinc-coated steel and consequently offers potential competition for such materials in the automotive, airplane, chemical, canning and construction industries.

Perhaps the most unusual feature of this material, called Alplate, is its ability to withstand indefinitely temperatures up to 1,000 deg. C. or approximately 1,800 deg. F. without destruction. Tests in which the material was subjected to that temperature for 1,000 hours showed that amount of deterioration of the aluminum coating was practically negligible. In other words, the material is not only corrosion resistant but also fireproof.

Aluminum coated steel has been used for electric resistance heating elements and is apparently as highly resistant to progressive oxidation at 1,800 deg. F. as it is at room-temperature. Screens woven from Alplate wire have been made into theater curtains, the curtains being completely fireproof as contrasted to the conventional asbestos curtains that require cotton thread to support the asbestos. Destruction of the cotton thread by heat may cause the curtain to fail.

Another outstanding characteristic of Alplate is the low density or weight of the metal coating per unit weight of steel coated, the coating weighing only about one-third the weight of an equal coating of tin or zinc. And as compared to solid aluminum, Alplate has a higher resistance to fatigue, the fatigue value being practically the same as that for solid steel. And where strength is the main specification, aluminum coated steel parts are 10 to 11 per cent lighter than solid aluminum parts of the same strength.

At present Alplate is available commercially in strips up to 18 in. wide and in wire in all commercial diameters. It is expected that a great many uses will be found for this new material. Its properties make it suitable for articles that must resist atmospheric corrosion, such as corrugated sheets for buildings, roofing, tanks for gas and gasoline, automobile parts such as fenders, radiator shells, tire rims, tops, running boards, etc., marine fittings, barbed wire fencing, railings, fly screening, architectural fittings for outdoors such as spandrels, indoor fittings such as molding, light fixtures and other applications.

It is also expected that in some applications, Alplate will be used in place of Alclad which is duralumin with a thin rolled-on coating of high-purity aluminum. By substituting a steel core in place of the duralumin core of the Alclad product, a sevenfold increase in tensile strength is attained. However, the aluminum coated material will be 3.3 times heavier than Alclad, hence for equal weights the Alplate will be about twice as strong as Alclad.

Welding Society Issues Filler Metal Specs

FURTHER progress leading to improved quality of weld metal is indicated in the new Filler Metal Specifications just released by the American Welding Society. This is indicated by the requirements for an ultimate strength of 80,000 lb. per sq. in. with an elongation of 20 per cent in 2 in., this being specified for minimum weld metal properties. Other requirements specified such as "free bend," "nick-breaks" and "density" are equally high when compared to previously accepted requirements.

Engineering designers who have to deal with corrosion problems will also find a wealth of data and information in the 44-page report of the American Welding Society. This report is devoted to "Corrosion Resistance of Welded Joints." The whole world was literally combed for test results and service experience dealing with the corrosion of welds in carbon and alloy steels and many of the non-ferrous metals. It is interesting to note that the report cites a number of instances wherein the welds stood up better than the base metal.

Illustrating how the adoption of new manufacturing processes frequently begins with their application to replacement and repair work, the editorial appearing in the August Monthly Research Report under the title "The Frontiers of Progress," states: "Quite early in its

history the petroleum industry became acquainted with welding as an emergency repair tool in preventing costly shutdowns in maintenance of tools and equipment and in the fabrication of its far flung oil pipe lines eliminating leaks and reducing maintenance costs. The welded storage tanks, tank trucks and cars followed in due course. To meet demands for ever increasing combinations of pressures and temperatures needed in increasing efficiency in oil cracking processes, improvement of quality and development of by-products, the oil industry turned to welding. Welded vessels four and five inches thick are taken as matters of course. In the march of progress carbon steels must give way to alloy and clad steels and the advance guard of welded carbon-molybdenum and other alloy steels for high temperatures, cutting thickness of plate to less than half, is well established. The future will exact still greater requirements from the petroleum industry and the welding industry will help meet those requirements."

New Auto Designs Continue Trends

CONTINUING the trend in the use of plastics that appeared in the 1937 models, the automobiles of 1938 will show a further increased use of this material. Die-cast radiator grilles which disappeared on a number of the 1937 models, are now sweeping back into favor. This year die-cast instrument panels are also coming into more extensive use as well as die-cast and chrome-plated headlamp rims. Advanced reports indicate that Chrysler cars will have a great many more die-castings than in previous models.

Increasing manufacturing costs have compelled automobile designers to a more economical use of materials. Thus although stainless steel will be used for a greater number of parts it is estimated that the weight per car will be less in the 1938 models because designers are cutting down the gage sizes wherever possible.

Previews of 1938 models reveal a number of interesting new design details, but major mechanical changes are few. Buick will feature "torque-free springing," which will utilize coil springs at the rear, the first time such springs have been used for rear springing. The development is believed to be a forerunner of some form of independent rear-wheel springing for other makes of cars in 1939.

An interesting Chrysler design feature contemplates seat cushion springs made of piano wire covered with latex. A number of manufacturers have taken the gear shift lever out of the center of the front compartment floor and put it up by the instrument board.

A complete account of the new designs developments incorporated in the 1938 automobile models will appear in the December number of *Product Engineering.*

Papers on Design at Metal Congress

WITH SIX national engineering societies convening at Atlantic City, N. J., October 18-22, there will be quite a number of papers of interest and value to designing engineers. In order that the readers of *Product Engineering* may take advantage of this, we are listing the following papers selected from the various programs.

Papers presented at sessions sponsored by the Wire Association will be published in the October number of *Wire and Wire Products.* Of special interest to designing engineers are the papers: "Fatigue Properties of Helical Springs" by R. R. Tatnall, engineer of the Morgan Works of Wickwire Spencer Steel Company; "Cold Heading" by L. S. Gooch, metallurgist of Buffalo Bolt Company; "High Nickel Alloys in the Field of Wire and Wire Products" by Carl Rolle, Development and Research Division, The International Nickel Company, Inc.; and "Cold Drawn Bars" by D. W. McDowell, metallurgist of Union Drawn Steel Company.

At the joint sessions of the American Institute of Mining and Metallurgical Engineers, together with the American Society of Metals, the American Society for Testing Materials and the American Institute of Physics, there will be a number of round table discussions on the physics of metals and metallography. At the session devoted to general metallurgy on Thursday morning, October 21, H. D. Newell will present a paper on "Effect of Silicon on Steels for High-Temperature Service" and H. L. Burghoff and D. E. Lawson on "Use of Tellurium in Copper-Base Alloys."

At the sessions under the auspices of the American Welding Society a number of papers, to be published in the official publication of that society, will be presented. "Weldability of Low Alloy Steels" by W. L. Warner of Watertown Arsenal; "Spot Welding Characteristics of Some Copper Base Alloys" by D. K. Crampton and J. J. Vreeland of Chase Brass & Copper Company; "Survey of Low-Alloy Steels as to Weldability" by J. H. Critchett of Union Carbide & Carbon Research Laboratories; and "Physical Properties and Corrosion Resistance of Nickel-Iron Alloys Formed in the Welding of Nickel-Clad Steel" by J. H. Deppler, W. G. Thiesinger and F. G. Flocke, are papers of special interest.

Other papers to be presented at the Welding Society sessions cover funda-

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MEETINGS

NATIONAL METAL CONGRESS—*Held in conjunction with the National Metal Show and participated in by five international societies, the American Society for Metals, the Iron & Steel Division, and the Institute of Metals Division of the American Institute of Mining & Metallurgical Engineers, the American Welding Society, the American Society of Mechanical Engineers, and the Wire Association. W. S. Eisenman, managing director, 7016 Euclid Ave., Cleveland, Ohio.*

Porcelain Enamel Institute—Annual meeting at Chicago, Ill., Oct. 11-12. Geo. P. MacKnight, secretary, 612 N. Michigan Ave., Chicago, Ill.

EXPOSITIONS

SIXTEENTH EXPOSITION OF CHEMICAL INDUSTRIES — *Grand Central Palace, New York, December 6–11. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.*

NATIONAL METAL SHOW—*Atlantic City Auditorium, Atlantic City, N. J., October 18–22. W. S. Eisenman, director, 7016 Euclid Ave., Cleveland, Ohio.*

NATIONAL AUTOMOBILE SHOW—*Grand Central Palace, New York City, October 27-November 3. Alfred Reeves, manager, 366 Madison Ave., New York, N. Y.*

Do You Know That—

HIGH-EFFICIENCY tungsten filaments, recently perfected, are made from wire 0.0019 in. in diameter, which is wound 335 turns per inch with a space of 0.001 in. between the turns? This coiled wire is in turn coiled 70 turns per inch, the final coil diameter, or the diameter of the final coil, being 0.031 in., and the length 5/8 in. This greatly concentrated filament makes possible 10 per cent more light for the same amount of electric current. (61)

GOVERNOR controlled a.c. series motors are coming into greater use. Advantages are not only speed control but maintenance of preset speed with increasing load. Turning a knob permits setting to speed desired. Used for some years on business machines, these motors are now being applied to household equipment. (62)

mental research in welding, a symposium on alloy steels and the application of welding to railroad equipment. Attention is called to the papers "Welding of Copper" by A. P. Young of Michigan College of Mining & Technology; "Carbon Arc Welding in Automotive Work" by William Richards of Chevrolet Motor Company; and "Automatic Resistance Welding" by Harry Landstrom of Nash-Kelvinator Corporation.

At the joint session of the American Welding Society with the American Society of Mechanical Engineers, J. M. Cooper of General Electric Company will present a paper on "Resistance Welding Fabrication," and C. C. Brinton of Westinghouse Electric & Mfg. Company will present a paper on "Developments in Large Welded Structures."

Papers to be presented at the sessions sponsored by the American Society for Metals will all deal primarily with carburizing.

In conjunction with the National Metal Congress there will be the Annual Metals Exposition held simultaneously.

Case Histories in Patent Law

H. A. TOULMIN, JR.

[Editor's Note: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr., wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law.*]

QUESTION: What determines whether a design involving an improvement on an old device is patentable, or an infringement?

ANSWER: There have been so many decisions holding that certain improvements are either not patentable or are actually infringements on previous patents that the idea is quite general among engineers and designers that an improvement is rarely patentable or worthwhile patenting.

The test, as always, is whether the improvement is at once, new, useful and the result of the inventive faculty rather than merely what would be expected from anyone skilled in the art. The parts may be old, but if the combination of them or their result be new, then there is invention.

TYPICAL CASES: A designer secured a patent on a device for mixing hot and cold water for shower baths. He claimed, rightly enough, that it required less piping and fewer valves with consequent saving in cost, elimination of inconvenience and discomfort arising from the manipulation of separate hot and cold water faucets. The court invalidated the patent, saying:

". . . the parts were all very old. Acting on his knowledge, skill and experience, he simply took another step in the evolution . . . we do not think his achievement was the result of the exercise of the inventive faculty."

In the July column, I cited the Langmuir patent for greatly improving the DeForest vacuum tube by increasing the degree of vacuum. In spite of the important results in the fields of telephony and radio communication the patent was invalidated because the relationship of high vacuum to the stability and effectiveness of the discharge, and the means of securing the high vacuum, were well known.

To increase the usefulness of a device by making it portable, adjustable, larger or more convenient, solely by changing its form, proportion or degree is not patentable. But if any of these changes make workable a device which formerly was not successful, it is invention.

Usually to increase the productivity of a machine is not invention, for it is natural for both the designer of the machine and its user to experiment constantly to increase production and reduce costs. If these results are achieved through the medium of routine improvements they are not patentable because the courts have frequently held that such improvements are what would be expected of the ordinary mechanic or engineer.

However, where a change results in unexpected and revolutionary increases in production it is patentable. A case in point is that of greatly increasing the pitch of the Fourdrinier wire in paper machines in order to improve the quality of product. Incidentally—and as it turned out this was the most important result—the change increased the productivity of paper machines more than 20 per cent.

Here are a few excerpts from court opinions as to when improvement is not invention.

". . . a mere carrying forward . . a change only in form, proportions or degree, the substitution of equivalents, doing substantially the same thing in the same way by substantially the same means, with better results, is not such invention as will sustain a patent.

Again: ". . . By this arrangement the sealing strip could be located away from the closure as far as was desired, but the step fell far short of invention. It involved adjustability only and adjustability is not invention."

"The process of development in manufactures creates a constant demand for new appliances, which the skill of ordinary head-workmen and engineers is generally adequate to devise and which, indeed, are the natural and proper outgrowth of such development. Each step forward prepares the way for the next, and each is usually taken by spontaneous trials and attempts in a hundred different places. To grant a single party a monopoly of every slight advance made, except where the exercise of invention somewhat above ordinary mechanical or engineering skill is distinctly shown, is unjust in principle and injurious in its consequences."

From what has been said it might appear that the inventor's chance of inventing something new, especially in the form of an improvement, is rather hopeless considering the highly crowded conditions of many mechanical and electrical arts. To some extent that is true, but the situation is not as hopeless as it seems, for the courts sustain the patenting of improvements when there is a real invention to be protected.

As far back as 1885 the Supreme Court of the United States recognized these conditions, which were hard enough then but are much more aggravated today. The decision in the Cantrell case, 29 L.Ed. 1017, reads, in part:

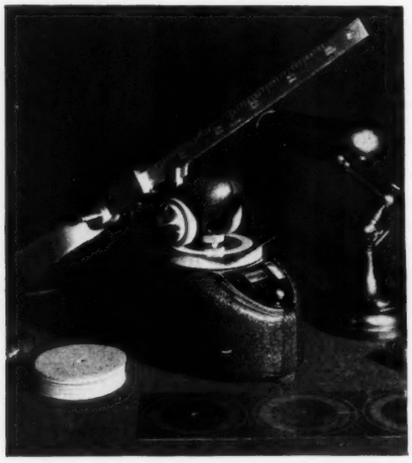
". . . the theory that a patent cannot be valid unless it is new in all its elements as well as in the combination . . . cannot be maintained. If it were sound, no patent for an improvement on a known contrivance or process could be valid. And yet the great majority of patents are for improvements in old and well-known devices or on patented inventions. Changes in the construction of an old machine which increase its usefulness are patentable."

Further on in its opinion the court included an important warning to designers who are working on improvements, when it said:

"Two patents may both be valid when the second is an improvement on the first, in which event, if the second includes the first neither of the two patentees can lawfully use the invention of the other without the other's consent."

New Materials and Parts

Precision Testing Machine



For measuring the wear resistance, toughness, adhesion and rub-off qualities of surface finishes such as enamels, electroplate, anodizing, linoleum, molded plastic sheets and leather coverings. It is especially useful in laboratory work for testing new formulas, control work, checking competitive samples, grading, etc. Tests to determine the comparative cutting efficiency of abrasive paper and cloth can also be made. The instrument is compact in design, light weight and portable. Taber Instrument Co., North Tonawanda, N. Y.

Paintgrip

A new galvanized iron or steel sheet that holds paint on a galvanized surface without acid-etching or weathering. The chemically treated surface not only holds the paint in a firm bond but also prevents cracking. Developed in cooperation with the Parker Rust-Proof Company of Detroit. The American Rolling Mill Co., Middletown, Ohio.

Mechanical Counter

A heavy-duty mechanical counter, Type MC-3-W, especially adapted to counting coil winding and similar operations. It has six large legible number wheels and is arranged for shaft drive. The count advances one number for each turn of the shaft and generally subtracts for each reverse revolution of the shaft. The reset knob returns all number wheels to zero with one revolution of the reset. The counter has a frame and case die cast of special alloy, designed for convenient mounting and to protect the counting mechanism. Positive and accurate operation is provided by an exclusive design of the drive action which prevents skip or coasting. Counter is 3⅝ in. long, 2⅝ in. high and 1¾ in. wide. Production Instrument Co., 1325 S. Wabash Ave., Chicago, Ill.

Sensitive D.C. Relay

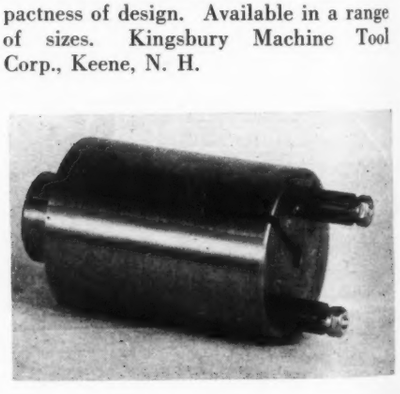
Especially designed for photocell amplifiers and other sensitive industrial control equipment. Special features include a plug-in base, low residual, iron frame and armature, precision layer wound coils, precision spring adjuster, full floating armature pivot, armature and contact screws reversible permitting normally open or normally closed arrangement, and fine silver contacts rated at 1 amp. 110 volts a.c. Made in single-pole, single-throw only with 2850 ohm coils. Acousto-Lite Laboratories, 2920 S. Vermont Ave., Los Angeles, Calif.

Spot Welding Electrodes

Two new spot welding electrode developments. First, cold formed electrodes, formed under tremendous pressure, are said to have a finer, more uniform grain structure with an additional 10 to 12 per cent increase in hardness, minimizing mushrooming or deformation of the tip. Second, plated electrodes have a thin electrically conductive coating of a special alloy resistant to oxidation. This is said to result in less heating of the electrode and consequently less softening and deformation. Electroloy Co., Inc., 50 Church St., New York, N. Y.

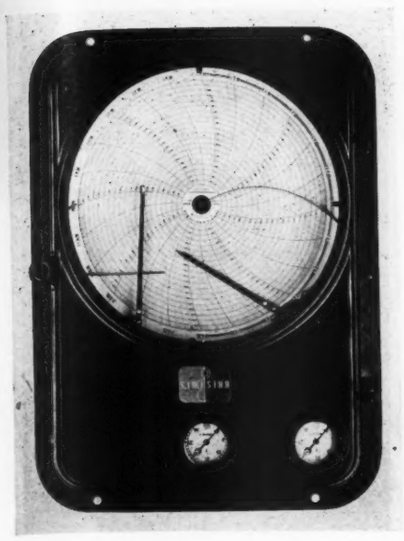
Novel A. C. Solenoid

The coil is wound directly on a phosphor-bronze bushing and is rigidly mounted in a cylindrical steel case to protect it from mechanical injury and to serve as a magnetic shield. Coils are impregnated with an oil and moisture-resisting compound. By virtue of a slotted solid plunger and pole piece construction variations in the character of the pull curve are obtained to meet individual requirements. Advantages claimed for the cylindrical construction include easy direct mounting in a round hole and advantages in cooling by virtue of the solid construction and compactness of design. Available in a range of sizes. Kingsbury Machine Tool Corp., Keene, N. H.



Pyrometer Controller

A new potentiometer pyrometer available in both pneumatic and electric types and using standard thermocouples and extension leads. Gives direct ink marking on a round 12-in. chart or may



be used for indicating on a large scale. It is claimed that the instrument operates on a simplified principle, requires no lubrication, is not affected by plant vibration. There is no mechanical motion of any kind except when a change in the measured temperature takes place. The controllers are automatically self-balancing and self-compensating for cold-end temperature changes and the actuation of the penarm takes place only when there is a change of temperature at the thermocouple thereby permitting immediate response to temperature changes as they occur. The instruments can be placed in a standard Bristol instrument case. The Bristol Co., Waterbury, Conn.

Rubber Tired Wheels

Of pressed steel construction with hardened steel inner and outer ball races. Wheels are rubber tired, the tire steamed into place. Type 70-RT is 2⅞ in. O.D., has ten 3/16 in. diam. balls and a rated capacity of 20 lb. Type 84-RT is 3½ in. O.D., has eleven 5/16 in. balls and a rated capacity of 50 lb.

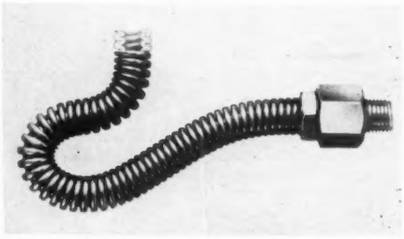
Designed to be suitable for not only conveying apparatus but also to serve as wheels and casters when mounted in a suitable frame. Mathews Conveyor Co., Ellwood City, Pa.

Fractional Hp. Motors

A new complete line of fractional horsepower motors in sizes from 1/6 to ¾ hp., repulsion start induction, single phase, split phase, capacitor, polyphase and direct current. Designed with interchangeable mounting dimensions for a given horsepower size. Century Electric Co., 1806 Pine St., St. Louis, Mo.

Triple Safe Tubing

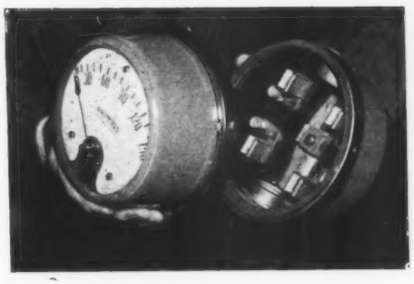
A new design of flexible seamless metal hose with the braid embedded between two corrugated seamless tubes, forming an all-metal, weldless, jointless and packless metal hose. All difficulties in cutting and attaching the braid are eliminated. Tubing is made of a special bronze alloy, non-corrosive, resistant to frequent flexing and severe vibration.



It can be made to order in aluminum. Available in standard sizes of ¼ in., 5/16 in., ⅜ in. and ½ in. I.D. with suitable fittings. Seamlex Co., 5-19 48th Ave., Long Island City, N. Y.

Plug-In Instruments

By merely plugging-in an ammeter, voltmeter, watthour meter or other instrument into the same self-supporting universal socket, it is possible to obtain a reading of any desired load condition



existing in the circuits of electrically powered machines. The socket is mounted directly in the wiring conduit and where more than one instrument is to be read at one time, standard "troughs" consisting of an all-metal box with several sockets can be used. The troughs are installed much like motor starters, and quick and easy mounting arrangements have been worked out for ordinary wiring, such as rigid conduit, open wiring or cable. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Opaque Typewriter Ribbon

Designed especially for photo-reproduction work, requires no carbon backing and will not smudge. Used for making master copies from which Ozalid white prints, blueprints, photostats, photo-engravings and photo-lithoprints are to be made. Because of the greater opacity of the ribbon, faster printing and more legible prints are possible. Ozalid Corp., 354 Fourth Ave., New York, N. Y.

Asbestos Cord Steam Hose

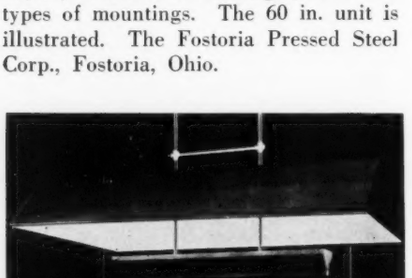
Made with four asbestos cord plies, wound spirally in alternating directions around a steam and heat-resisting tube and embedded in rubber. Its ply construction eliminates all possibility of shearing action when the hose expands or is flexed in service. The asbestos cords will not char under high temperatures and the black heat-resisting cover is specially compounded for superheated steam service. Available in the following sizes, all four ply: ½ in., ¾ in., 1 in., 1¼ in. and 1½ in. I.D., accommodating pressures ranging from 175 to 200 lb. Maximum lengths are 50 ft. New York Belting & Packing Co., 1 Market St., Passaic, N. J.

High Ductility Alloy Steel Rod

A new gas welding rod, designed to meet the demand for increased ductility and general improvement in quality of both single and multi-layer steel welds. An outstanding feature of the new rod is its ability to withstand considerable heating without burning. Physical characteristics include: free bend ductilities of single layer welds, range from 20 to 30 per cent depending upon the composition of the steel; free bend ductilities of multi-layer welds, up to 40 per cent on low and medium carbon steels; ultimate tensile strengths in excess of 60,000 lb. per sq. in.; specific gravity of welds, 7.80 — 7.86; charpy impact values on keyhole notched specimens at 70 deg. F., from 15 to 30 ft. lb.; Rockwell hardness of weld metal from B60 to B85, depending on carbon content of base metal and type of weld. Air Reduction Sales Co., Lincoln Bldg., New York, N. Y.

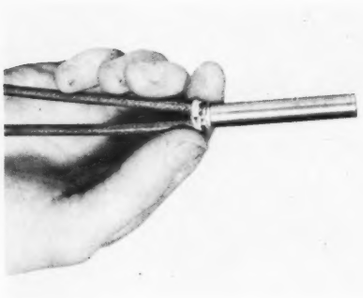
Canopy Lighting Unit

Developed to provide a relatively large spread of diffused illumination with a minimum of brightness and glare from the light source. Recommended for use in such operations as bright metal scribing, drafting, inspection work, typesetting, engraving or any operation where highly diffused illumination is desired. Available in four sizes, 20, 28, 40 and 60 in. in length, in several types of mountings. The 60 in. unit is illustrated. The Fostoria Pressed Steel Corp., Fostoria, Ohio.



Cartridge-Type Heating Unit

For use where a "spot" of heat is required within a limited space. The unit is 3/8 in. in diam. and is manufactured with brass sheath for maximum operating temperature of 750 deg. F. Es-



pecially convenient for built-in applications and can be quickly installed. Available in rating of 30, 75 and 90 watts at 115 or 230 volts, a.c. or d.c. General Electric Co., Schenectady, N. Y.

Magnesium Die-Casting Alloys

An addition to their list of die-casting alloys, which includes tin, lead, zinc, aluminum and copper base alloys. Three magnesium alloys having a tensile strength of up to 35,000 lb. per sq. in. and an elongation of up to 10 per cent have been standardized. Other alloys are also available to meet special service requirements. The addition of magnesium to the list of available die-casting alloys combines the labor saving feature of the die-casting process with the weight saving feature of magnesium. The Doehler Die Casting Co., 386 Fourth Ave., New York, N. Y.

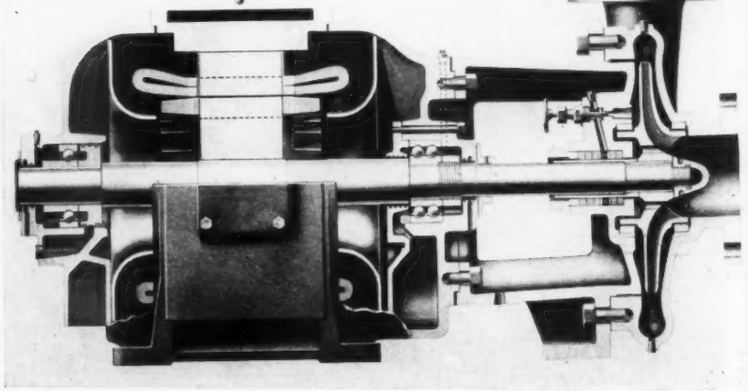
Vari-Speed Motor Pulley

In this improved design the adjustable disk V-belt pulley can be mounted in the center of the countershaft between the two bearing housings thus providing a more compact space-saving unit. While a straight-face pulley is illustrated, power take-off may also be from sprocket, pinion, multiple V-belt, sheave or other type of drive. In its operation rotating the handwheel control causes the motor to slide on its base, thereby varying the diameters of a set of adjustable disks from which the V-belt runs to the driven machine. Built in

seven sizes for transmitting from fractional to 7½ hp. and covering speed ratios of from three to one. Reeves Pulley Co., Columbus, Ind.

Motor-Mounted Pump

Only one shaft and two bearings are used in each of the compact, self-contained pumping units comprising this recently introduced line. The centrifugal pump is mounted upon the end bell of the electric motor and can be installed with the shaft horizontal, vertical, or inclined. All pump parts can be removed without disturbing the motor. Parts subject to wear are made interchangeable and replacements can be inserted without having to be fitted. Pump casing is of cast iron, while the impeller wearing ring, shaft sleeve, stuffing-box gland and lantern ring are of bronze. Available for capacities of from 5 to 1,200 gal. per min. and for heads of from 10 to 230 ft. De Laval Steam Turbine Co., Trenton, N. J.



Manufacturers' Publications

BEARINGS — Johnson Bronze Co., New Castle, Pa. Wall Card, 17x11 in., folded to 8½x11 in. A ready reference chart giving complete information on over 200 sizes of cast bronze graphited bearings with valuable information covering their applications, tolerances and alloys.

BEARINGS — Norma-Hoffmann Bearings Corp., Stamford, Conn. Catalog No. F-958, 84 pages, 8½x11 in. Describing complete line of precision ball, roller and thrust bearings. Tabulated data on sizes, dimensions and load ratings of 108 series of precision bearings is presented, together with engineering data including cross-sectional drawings of typical applications, full bearing tolerances, instructions for mounting, lubrication and protection, etc.

BERYLLIUM COPPER—The Riverside Metal Co., Riverside, N. J. Revised booklet, 28 pages, 8¾x11¼ in. Containing pertinent information on beryllium copper including composition, forms available, properties, heat-treatment, fabrication, etc. Numerous pictures effectively illustrate by means of color many beryllium applications.

CONTROLS—The Mercoid Corp., 4213 Belmont Ave., Chicago, Ill. 16 pages, spiral bound. A sales brochure, "Built to Endure," illustrating and describing Mercoid controls, including the Sensatherm thermostat, Pyratherms, line safety controls, limit and low water controls for steam boilers, temperature limit controls, warm air furnace controls and sealed mercury contact switches.

DROP-FORGED TOOLS—J. H. Williams & Co., 75 Spring St., New York, N. Y. Catalog, 184 pages, 4x6 in. Describing their entire industrial line of drop-forged wrenches and other standard stock specialties.

DUALSTEEL UNIONS—Rockwood Sprinkler Co., 38 Harlow St., Worcester, Mass. Folder, 9x12 in. Details on special features of Dualsteel unions, advantages and applications in various fields.

ELECTRIC EQUIPMENT—Bull Dog Electric Products Co., Detroit, Mich. Catalog, 95 pages, 8½x10 in. A condensed catalog of Bull Dog equipment including Vacu-Break safety switches, meter service switches, service equipment, switch-centers, lighting panels, Nofuse circuit breaker material, etc.

ELECTRIC METERS—The Brown Instrument Co., Philadelphia, Pa. Catalog No. 3005, 24 pages, 8 x 10½ in. Covers the complete line of Brown indicating and recording Co_2 meters and also combined Co_2 and flue gas temperature recorders.

ELECTROPLATING RECTIFIERS—Hanson-Van Winkle-Munning Co., Matawan, N. J. Bulletin ER-101, 4 pages, 8½x11 in. Information on construction, installation and operation of copper oxide plate type rectifier units for converting a.c. into d.c. for electroplating.

ETHYL CELLULOSE PLASTICS—Hercules Powder Co., Inc., Wilmington, Del. Booklet, 8 pages, 7½x10½ in. Discusses the use of ethyl cellulose in plastics.

FLEXIBLE COUPLINGS—Thomas Flexible Coupling Co., Warren, Pa. Catalog No. 35, Second Edition, 64 pages, spiral bound, 6x8¾ in. Covering their line of flexible couplings including descriptive data, illustrations, dimensional drawings and specifications.

FLEXIBLE LACQUER — Roxalin Flexible Lacquer Co., Elizabeth, N. J. 3 folders, 9x11 in. Product summaries giving the properties of the following clear, cellulose type, air-drying lacquers: tarnish-proof lacquer No. 4527, outdoor lacquer No. 4917, and buffing lacquer No. 950.

FLOW METERS—Foxboro Co., Foxboro, Mass. Bulletin No. 200-2, 49 pages. A comprehensive bulletin on flow meters for steam, liquids and gas, including descriptive data on various types, construction details, charts and specifications, uses, etc.

GEARS—Continental Diamond Fibre Co., Newark, Del. Bulletin, 8 pages, 8½x11 in. Descriptive data on Celoron silent gears, including a table of horsepower rating.

GEARS—Bilgram Gear & Machine Works, 1217-1235 Spring Garden St., Philadelphia, Pa. Booklet, 8 pages, 6¾x9½ in. General information for specifying elliptic gears.

HEAT-TREATMENT — The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Nickel Cast Iron Data, Section 3, No. 7. 15 pages, 8½x11 in. Information on heat-treatment fundamentals of nickel, plain, nickel-chromium and nickel-chromium-molybdenum cast irons.

HERCULOY—Revere Copper and Brass Incorporated, 230 Park Ave., New York, N. Y. Booklet, 64 pages, 8½x11 in. Following a section devoted to general information concerning Herculoy, specific data pertaining to the physical characteristics of Herculoy in its various fabricated forms are presented. Booklet is well illustrated with many striking pictures and useful charts of physical properties. Also includes a table of chemical and physical properties of Revere alloys.

HYDRAULIC EQUIPMENT—The Tomkins-Johnson Co., Jackson, Mich. Catalog H-37, 24 pages, 9x11½ in. Detailed information and specifications on the T-J line of hydraulic cylinders, power units and special equipment. Also devotes a section to engineering data.

INSULATION—Johns-Manville, 22 East 40th St., New York, N. Y. Booklet, 68 pages, 3½x6 in. A new edition of the booklet "Barriers to Industrial Waste." Contains a complete table of recommendations for the proper selection of J-M insulations for uses in practically all industries. More than 50 different insulations for all types of heated or refrigerated equipment are described.

MONEL—The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Bulletin T-12, 16 pages, 8½x11 in. Data on machining Monel, Nickel and Inconel.

MOTORS—The Louis Allis Co., Milwaukee, Wis. Bulletin No. 700, 60 pages, 8½x11 in. Describing the construction, features, advantages and applications of practically every commercial type electric motor. Also includes engineering data on various types of special motor applications.

PIPE UNIONS AND FITTINGS—E. M. Dart Mfg. Co., Providence, R.I. Catalog, 12 pages, 8½x11 in. An effectively presented and illustrated catalog on Dart pipe unions and fittings including details on their manufacture, dimensional tables and an illustrated listing of types available.

PULLEYS—Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. Booklet No. 1622, 8 pages, 8½x11 in. Illustrated list price booklet on cast iron pulleys for power transmission, giving pertinent data on solid and split, single and multiple arm machine-molded pulleys, with and without rubber lagging.

PYROMETERS—Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Broadside N-33. Presenting choice of four distinct pyrometer types, including the new Rayotube pyrometer, to meet conditions of practically any plant problem. The complete line of Micromax and other Leeds & Northrup pyrometer instruments are illustrated and briefly described.

RELAYS AND SWITCHES—The Hart Mfg. Co., Hartford, Conn. Bulletin, 8½x11 in. Engineering data on "Diamond H" mercury tube relays and switches.

RESISTORS—International Resistance Co., 401 N. Broad St., Philadelphia, Pa. Resistance engineering guide containing complete resistor information for engineers and designers of electric and electronic equipment. Also includes such information as power formulas, Ohm's law, resistor color code chart, etc.

ROLLER CHAIN DRIVES—Renold Div., Boston Gear Works, Inc., North Quincy, Mass. Catalog RD, 45 pages, 8½x11 in. Complete listing and prices on their line of Renold roller chain drives and accessories. Actual size chain illustrations, engineering data and various selection charts are included.

SILENT CHAIN DRIVES—Morse Chain Co., Ithaca, N. Y. Bulletin No. 49, 20 pages, 8½x11 in. Containing engineering data frequently required in planning and specifying silent chain drives. Includes horsepower tables, explanation of different types of silent chains and their applications, layout of typical shoes and idlers, sprocket data, directions for cutting sprockets, how to calculate chain length, special sprockets and their uses, chain cases and methods of oiling.

SPEED REDUCERS—Boston Gear Works, Inc., North Quincy, Mass. Catalog No. 101, 98 pages, pocket size. A new catalog of "Ratiomotors" and "Reductors," including also a full line of flexible couplings, a new line of miter gear units and engineering data on the selection of speed reducing equipment.

SPEED REDUCERS—Foote Gear Works, Inc., 1301 S. Cicero Ave., Cicero, Ill. Catalog, 72 pages, 8½x11 in. Devoted primarily to heavy-duty worm gear and herringbone speed reducers including specifications, price lists and tables of ratings. Also includes data on flexible couplings.

SPIRAL WELDED PIPE—The American Rolling Mill Co., Middletown, Ohio. Booklet, 44 pages, spiral bound. Technical information, installation data an advantages of ARMCO spiral welded pipe are covered in "6 to 36 Inch Pipe for Industrial Uses."

SWITCHING APPARATUS—General Electric Co., Schenectady, N. Y. Bulletin, 20 pages, 8x10½ in. Presenting in tabloid form 137 G-E switching items. Illustrations of each product are included with concise descriptions of applications, ratings and features.

TESTING MACHINE—Taber Instrument Co., North Tonawanda, N. Y. Bulletin 637, 8 pages, 8½x11 in. Complete details of construction and operation of the Taber abraser for measuring the wear resistance, toughness, adhesion and rub-off qualities of finishes.

TIME CONTROLS—Paragon Electric Co., 37 W. Van Buren St., Chicago, Ill. Bulletin 3745, 8½x10 in. Condensed catalog of Paragon time controls for the heating, air-conditioning and refrigeration industry, including illustrations and brief descriptions.

VIBRATING-REED TACHOMETER — James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa. Bulletin 1510, 12 pages, 7¾x10½ in. Complete details and price list on "Frahm" vibrating-reed tachometers for measuring speeds up to 30,000 r.p.m.

VIBRATION—Sundt Engineering Co., 4238 Lincoln Ave., Chicago, Ill. Describing the Neobeam Oscilloscope and auxiliary equipment for analyzing and measuring vibration, noise levels, magnetic balancing, etc.

WASHER DATA CHART—Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee, Wis. New specification table, printed on heavy index bristol, suitable for hanging. Contains complete size and dimension data of the entire range of standard wrought washers. More frequently used washers are illustrated in exact size.

WELDING—The Lincoln Electric Co., Cleveland, Ohio. Bulletin, 12 pages, 8½x11 in. "Welding in Construction Work" is an interesting and informative record of a variety of recent construction projects which utilized electric welding, describing in detail the work done.

WELDING GUNS—Progressive Welder Co., 737 Piquette, Detroit, Mich. Catalog, 8 pages, 8½x11 in. Data on hydraulic welding guns and equipment and their application. A series of line drawings presents the variety of welding guns available.

Books and Bulletins

How to Make Alignment Charts

MERRILL G. VAN VOORHIS. *116 pages, 6x9 in. Blue clothboard covers. 80 illustrations. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $2.50.*

Writing to meet the needs of practising engineers, the author has well succeeded in his aim to present a book that shows how to make alignment charts for the solution of engineering formulas, as contrasted to a book that explains the theory of their construction. Thus, Mr. Van Voorhis has produced a book which enables the practical engineer to construct charts for engineering formulas without the necessity of first delving into and mastering the theory of their construction. This he did by showing the detailed procedure in the construction of nomograms for 19 types of equations, the construction of their nomograms being demonstrated by the charting of 41 typical engineering formulas.

For the benefit of the studious engineer who might wish to delve into the theory of construction, the theory is briefly outlined in a 17-page appendix.

With the treatment arranged so that equations or formulas can be matched with the listed type forms and the nomogram constructed by following the instructions given, the practical engineer is enabled to build his chart even without a knowledge of the theory of their construction.

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Applied Fluid Mechanics

MORROUGH P. O'BRIEN AND GEORGE H. HICKOK. *360 pages, 6x9 in. Red clothboard covers. 166 illustrations, 22 tables. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.50.*

The authors have presented in this book a thorough-going discussion of the theories and principles common to a study of the mechanics and dynamics of liquids and gases in motion.

After a consideration of the basic principles involved in hydrostatics, the subject of flow phenomena is examined in detail. This is followed by the development of the equation for frictionless motion of fluids in undirectional flow systems. These equations are modified to conform with the physical effects of viscosity in the chapter entitled "Viscosity, Turbulence and Friction." The relationships between the rate of discharge and measurable variable connected with the total head are treated under the heading "Weirs, Orifices and Gates." Forces exerted on objects by fluids; flow and losses in hydraulic pipelines; and flow in open channels are each taken up in turn with the development of characteristic equations.

A reference bibliography is appended to each chapter for the use of readers and students who wish to study the subjects presented in greater detail. Problems are included for practice in applying the principles and the equations developed.

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Test for Acid Resistance of Porcelain Enamels

TENTATIVE STANDARD OF THE PORCELAIN ENAMEL INSTITUTE. *12 pages, 8½x11 in. Published by the Technical Research Section, Educational Bureau, Porcelain Enamel Institute, 612 N. Michigan Ave., Chicago, Ill. Price 10 cents.*

Described in this new publication are the "room temperature test" and "boiling test." Complete instructions are given under each classification for simple methods of determining the acid resistance of porcelain enamels.

Syan Blue B

A report from the Research Laboratories of the International Printing Ink Corporation. 48 pages, 9½x11½ in. Distributed by Ault & Wiborg Corp., 75 Varick St., New York, N. Y.

The first comprehensive laboratory report on the characteristics and applications of Syan Blue B, a product of the first new blue pigment in more than a century. Its properties of fastness make it particularly well suited to applications which require a color resistant to sunlight, heat and chemical reagents and it is said to be superior in many ways to existing blues.

The report is divided into three parts. First, a general description of Syan Blue B and its possibilities; second, its fields of application, comparing in each instance the properties of the new pigment with blues now being used; and third, an appendix containing a summary of the reports prepared by the various laboratories who investigated this pigment.

Tin Research

Recent report published by the International Tin Research and Development Council. Copies are available free from L. J. Tavener, 149 Broadway, New York, N. Y.

"The Decoration of Tinplate by Printing and Varnishing" by W. E. Hoare. Series B, No. 4, 24 pages.

PRODUCT ENGINEERING + REFERENCE BOOK SHEET

Formulas for Combined Stress

Table of Equations and Example of Use

RAYMOND J. ROARK
Professor of Mechanics, University of Wisconsin

WHEN A structural or machine element is subjected to tension, compression or shear, or to a combination of these, it is often necessary to calculate the stresses produced on some particular plane of weakness, or to calculate the intensity and direction of the maximum stresses that result from the combination. Thus the strength of an axially loaded wood strut may be determined by the shear stress parallel to the plane of the grain, and a shaft subjected to simultaneous bending and twisting must be so designed that the resultant tensile and shear stresses do not exceed allowable values.

In most instances the normal (tensile or compressive) and shear stresses on each of three mutually perpendicular planes at a given point can be readily calculated by ordinary methods. The accompanying table gives formulas by which can be found the resulting normal stress S_n and shear stress S_p on any given plane; the maximum and minimum normal stresses (called principal stresses); the planes on which the principal stresses occur (called principal planes); and the maximum shear stress. All stresses are unit stresses and are positive when acting as shown, negative when acting in opposite direction.

The figures incorporated in the table represent cubes of infinitesimal dimensions acted on by applied normal stresses s, s_1, s_2, s_3 and applied shear stresses s_s, s_{s1}, s_{s2}, s_{s3} which are determinable from the conditions of the problem. For example, the applied normal stress may be caused by direct tension or compression, or by flexure; the applied shear stress by direct shear or by twisting. In any instance, the X, Y and Z axes may be so chosen as to make possible the calculation of these applied stresses.

Example

A piece of "standard extra strong" pipe, 2 in. in nominal diameter, is simultaneously subjected to an internal pressure of 2,000 lb. per sq. in. and to a twisting moment of 5,000 in. lb. caused by tightening a cap screwed on at one end. It is desired to determine the maximum tensile stress and the maximum shear stress thus produced in the pipe. The calculations will be made (a) for a point at the outer surface and (b) for a point at the inner surface.

Dimensions of the pipe and properties of the cross-section are as follows: Inner radius $R_1 = 0.9695$ in.; outer radius $R_2 = 1.1875$ in.; cross-sectional area of bore $A_b = 2.955$ sq. in.; cross-sectional area of pipe wall $A_w = 1.475$ sq. in.; polar moment of inertia $J = 1.735$ in.^{4} We take the X axis parallel to axis of pipe, Y axis tangent to cross-section, Z axis radial, and let p denote the internal pressure.

For Outer Point: For the point at the outer surface, the stress conditions are those of Case 5: s_1 is the longitudinal tension caused by internal pressure, s_2 is the circumferential tension caused by internal pressure, and s_s is the shear stress caused by torsion. Calculating s_1 by the formula for axial loading, s_2 by the formula for thick cylinders, and s_s by the torsion formula, we have:

$$s_1 = pA_b/A_w = (2{,}000)\ (2.955)/1.475 = 4{,}000$$

$$s_2 = \frac{PR_1^2\ (R_2^2+R_2^2)/R_2^2\ (R_2^2-R_1^2)}{} = \frac{(2.000)\ (0.9659^2)\ (1.1875^2+1.1875^2)}{1.1875^2\ (1.1875^2-0.9659^2)} = 8{,}000 \text{ lb. per sq. in.}$$

$$s_s = T\,R_2/J = (5{,}000)\ (1.1875)/1.735 = 3{,}420 \text{ lb. per sq. in.}$$

Principal stresses

$$= \frac{1}{2}(s_1+s_2) \pm \sqrt{\left(\frac{s_1-s_2}{2}\right)^2+s_s^2}$$

$$= \frac{1}{2}(4{,}000+8{,}000) \pm \sqrt{\left(\frac{4{,}000-8{,}000}{2}\right)^2+3{,}420^2}$$

= 9,970 and 2,030 lb. per sq. in., both tensile.

The maximum tensile stress is therefore 9,970 lb. per sq. in.

$$\text{Maximum } s_p = \sqrt{\left(\frac{s_1-s_2}{2}\right)^2+s_s^2} = \sqrt{\left(\frac{4{,}000-8{,}000}{2}\right)^2+3{,}420^2}$$

= 3,970 lb. per sq. in.

For Inner Point: For the point at the inner surface, the stress conditions are those of Case 7. Stress s_1 is the longitudinal tension caused by internal pressure, s_2 is the circumferential tension caused by internal pressure, s_3 is the compressive stress caused by the direct pressure p against the inner surface; $s_{s1} = 0$, $s_{s2} = 0$, and s_{s3} is the shear stress caused by torsion. Also, s_1 and s_2 are positive; s_3 is negative; s_{s3} may be taken as either positive or negative, since the direction of the torsional shear on the elementary cube depends on the assumed sense of the twisting moment and the point of view; and since s_{s3} is squared in the equations, its sign is immaterial. Then:

s_1 = 4,000 lb. per sq. in., as above

$$s_2 = p\,(R_2^2+R_1^2)/(R_2^2-R_1^2) = \frac{2.000\ (1.1875^2+0.9659^2)}{(1.1875^2-0.9659^2)} = 10{,}000$$

$$s_{s3} = T\,R_1/J = (5{,}000)\ (0.9659)/1.735 = 2{,}790 \text{ lb. per sq. in.}$$

$$s^3 - (4{,}000+10{,}000-2{,}000)\,s^2 + [(4{,}000)\ (10{,}000) + (10{,}000)\ (-2{,}000) + (4{,}000)\ (-2{,}000) - 0 - 0 - 2{,}790^2]\,s - [(4{,}000)\ (10{,}000)\ (-2{,}000) + 0 - 0 - 0 - (-2{,}000)\ (2{,}790^2)] = 0$$

The three roots of this equation give the three principal stresses, which are:

$s = +11{,}100$, $s = +2{,}900$, $s = -2{,}000$ lb. per sq. in.

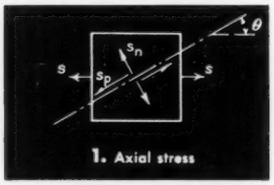
For this case, with $s_{s1} = 0$ and $s_{s2} = 0$, the first two of these stresses are in the XY plane; the third is simply s_3. Finally:

$$\text{Max. } s_p = \frac{1}{2}\left[11{,}100-(-2{,}000)\right] = 6{,}550 \text{ lb. per sq. in.}$$

The equations given in the table are standard formulas with which students of elasticity are familiar. However, most text books on strength of materials do not give all of them and books on the general theory of elasticity do not give them in such form and notation as to be most convenient for use by the average designer.

CONDITION OF STRESS

Normal stress S_n, shear stress S_p, principal stresses, and maximum shear stress.



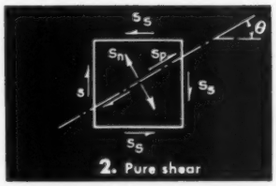
1. Axial stress

$s_n = s \sin^2 \theta$

$s_p = \frac{1}{2} s \sin 2\theta$

Principal stresses $= s$ and 0 (when $\theta = 90°$ and $0°$)

Max. $s_p = \frac{1}{2} s$ (when $\theta = 45°$ and $135°$)



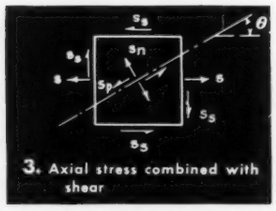
2. Pure shear

$s_n = s_s \sin 2\theta$

$s_p = s_s \cos 2\theta$

Principal stresses $= +s_s$ and $-s_s$ (when $\theta = 45°$ and $135°$)

Max. $s_p = s_s$ (when $\theta = 0°$ and $90°$)



3. Axial stress combined with shear

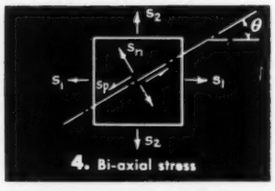
$s_n = \frac{1}{2} s (1 - \cos 2\theta) + s_s \sin 2\theta$

$s_p = \frac{1}{2} s \sin 2\theta + s_s \cos 2\theta$

Principal stresses $= \frac{1}{2} s \pm \sqrt{\left(\frac{1}{2} s\right)^2 + s_s^2}$ $\left(\text{when } \theta = \frac{1}{2} \text{ arc tan } \frac{-2 s_s}{s}\right)$

Max. $s_p = \sqrt{\left(\frac{1}{2} s\right)^2 + s_s^2}$ $\left(\text{when } \theta = \frac{1}{2} \text{ arc tan } \frac{s}{2 s_s}\right)$

(Planes of max. shear stress are at 45 deg. to principal planes.)



4. Bi-axial stress

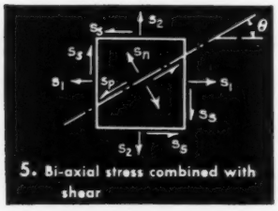
$s_n = s_1 \sin^2 \theta + s_2 \cos^2 \theta$

$s_p = \frac{1}{2} (s_1 - s_2) \sin 2\theta$

Principal stresses $= s_1$ and s_2 (when $\theta = 90°$ and $0°$)

Max. $s_p = \frac{1}{2} (s_1 - s_2)$ (when $\theta = 45°$ and $135°$)

This is the maximum shear stress on any plane normal to the common plane of s_1 and s_2, but when s_1 and s_2 are of opposite signs the greatest shear stress occurs on a plane parallel to the lesser of these stresses, is inclined at 45° to the greater, and equals half this greater stress.



5. Bi-axial stress combined with shear

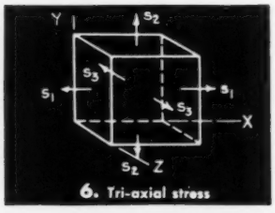
$s_n = \frac{1}{2} (s_1 + s_2) + \frac{1}{2} (s_2 - s_1) \cos 2\theta + s_s \sin 2\theta$

$s_p = \frac{1}{2} (s_1 - s_2) \sin 2\theta + s_s \cos 2\theta$

Principal stresses $= \frac{1}{2} (s_1 + s_2) \pm \sqrt{\left(\frac{s_1 - s_2}{2}\right)^2 + s_s^2}$ $\left(\text{when } \theta = \frac{1}{2} \text{ arc tan } \frac{2 s_s}{s_2 - s_1}\right)$

Max. $s_p = \sqrt{\left(\frac{s_1 - s_2}{2}\right)^2 + s_s^2}$ $\left(\text{when } \theta = \frac{1}{2} \text{ arc tan } \frac{s_1 - s_2}{2 s_s}\right)$

(Planes of max. shear stress are at 45 deg. to principal planes.)



6. Tri-axial stress

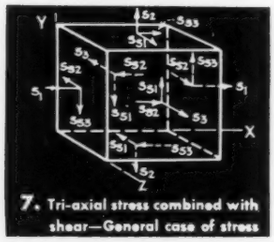
Let l, m, n be the cosines of the angles made by any axis OX' with the axes OX, OY, and OZ respectively. Then on a plane normal to OX':

$s_n = s_1 l^2 + s_2 m^2 + s_3 n^2$

$s_p = \sqrt{s_1^2 l^2 + s_2^2 m^2 + s_3^2 n^2 - s_n^2}$

Principal stresses are s_1, s_2, and s_3.

Max. s_p occurs on each of the two planes inclined at 45 deg. to the two principal stresses whose algebraic difference is greatest, and is equal to $\frac{1}{2}$ that algebraic difference.



7. Tri-axial stress combined with shear—General case of stress

Let OX', OY', OZ' be rectangular axes with origin at O. OX' makes with OX, OY, OZ angles whose cosines are l_1, m_1, n_1; OY' makes with OX, OY, OZ angles whose cosines are l_2, m_2, n_2; OZ' makes with OX, OY, OZ angles whose cosines are l_3, m_3, n_3. Then on a plane normal to OX':

$s_n = l_1^2 s_1 + m_1^2 s_2 + n_1^2 s_3 + 2\, m_1 n_1 s_{s1} + 2\, n_1 l_1 s_{s2} + 2\, l_1 m_1 s_{s2}$

s_{py} (shear stress parallel to OY') $= l_1 l_2 s_1 + m_1 m_2 s_2 + n_1 n_2 s_3 + s_{s1}\,(m_2 n_1 + m_1 n_2) + s_{s2}\,(n_2 l_1 + n_1 l_2) + s_{s3}\,(l_2 m_1 + l_1 m_2)$

s_{pz} (shear stress parallel to OZ') $= l_1 l_3 s_1 + m_1 m_3 s_2 + n_1 n_3 s_3 + s_{s1}\,(m_3 n_1 + m_1 n_3) + s_{s2}\,(n_3 l_1 + n_1 l_3) + s_{s3}\,(l_3 m_1 + l_1 m_3)$

s_p (resultant shear) $= \sqrt{(s_{py})^2 + (s_{pz})^2}$

The three principal stresses s are given by the three roots of the equation:

$s^3 - (s_1 + s_2 + s_3)\, s^2 + (s_1 s_2 + s_2 s_3 + s_1 s_3 - s_{s1}^2 - s_{s2}^2 - s_{s2}^2)\, s - (s_1 s_2 s_3 + 2\, s_{s1} s_{s2} s_{s3} - s_1 s_{s1}^2 - s_2 s_{s2}^2 - s_3 s_{s1}^2) = 0$

The direction of each principal stress is defined by the cosines l, m, n of the angles it makes with OX, OY, OZ and these direction cosines are found by substituting the value of the s in question in the following equations:

$(s - s_1)\, l - s_{s3}\, m - s_{s2}\, n = 0$; $-s_{s3}\, l + (s - s_2)\, m - s_{s1}\, n = 0$; $-s_{s2}\, l - s_{s1}\, m + (s - s_3)\, n = 0$ and solving for l, m, and n.

The maximum shear stress occurs on each of the two planes inclined at 45 deg. to the two principal stresses whose algebraic difference is greatest, and is equal to $\frac{1}{2}$ that algebraic difference.